9th Physics (English Medium)

Chapter # 1:

Physical Quantities and Measurement

- **Q. Choose the correct answer from the following choices:**

i. The number of base unit is SI is.(SW 14-I) (BP, FB 15-II) (LHR 08-II) (LHR, AK 13-II)
(a) 3 (b) 6 (c) 7 (d) 9

ii. Which one of the following unit is not a derived unit?
(SG, LHR 14-I) (RWP 13-II) (GW 10-I) (AK 15-I) (DG 15-II)
(a)pascal (b) kilogram (c) newton (d) watt

iii. Amount of a substance in terms of numbers is measured in.
(DG 13-I) (SG, DG 14-I) (FB 15-I)
(a)gram (b) kilogram (c) newton (d) mole

iv. An interval of 200μs is equivalent to. (SW 14-II) (RWP 13-I)
(a) 0.2s (b) 0.02s (c) 2×10^{-4}s (d) 2×10^{-6}s

v. Which one of the following is the smallest quantity?
(LHR, MN 14-II) (GW 13-II) (BP 14-I) (MN 15-I)
(a)0.01g (b) 2mg (c) 100μg (d) 5000ng

vi. Which instrument is most suitable to measure the internal diameter of a test tube?
(BP 14-II) (SG 13-II) (DG 14-I)
(a)metre rule (b)vernierCallipers (c) measuring tap (d) screw Guage

vii. A student claimed the diameter of a wire as 1.032cm using Vernier Callipers. Upto what extent do you agree with it?
(a) 1cm (b) 1.0cm (c) 1.03cm (d) 1.032cm

viii. A measuring cylinder is used to measure.
(BP 14-II) (FB 13-II, 14-I) (MN 15-I)
(a)mass (b) area (c)volume (d) level of a liquid

ix. A student noted the thickness of a glas sheet using a screw gauge. On the main scale, it reads 3 division while 8th division on the circular scale coincides with index line. Its thickness is.
(a) 3.8cm (b) 3.08mm (c) 3.8mm (d) 3.08mm

x. Significant figures in an expression are.
(a)all the digits (b) all the accurately known digits
(c)all the accurately known digits and the first doubtful digit
(d)all the accurately known and the doubtful digits

ANSWER:

i.	c.	ii.	b.	iii.	d.	iv.	c.	v.	d.
vi.	b.	vii.	c.	viii.	c.	ix.	b.	x.	c.

Short Questions

- **Write short answers of the following questions:**

1.1. What is the difference between base quantities and derived quantities? Give three examples in each case. (GW 14-I) (GW, LHR, SG 13-II) (SW 13-I) (SW, MN, SG 14 I-II) (RWP, FB, LHR 15-I) (RWP, FB 15-II) (LHR 09-I) (BP 12-I) (BP II-II)

Ans:

Base quantities	Derived quantities
• Base quantities are the quantities on the basis of which other quantites are derived.	• The quantites that are expressed in terms of base quantities are called derived quantities.
Example:	**Example:**
Length, mass, time, electric current, temperature, intensity of light and amount of substance.	Volume, speed, force, work, energy, power and electric charge.

1.2. Pick out the base units in the following:
Joule, Newton, Kilogram, Hertz, Mole, Ampere, Metre, Kelvin, Coulomb and Watt.

Ans: **Base Units:** Kilogram, mole, ampere, metre and kelvin and the base units.

1.3. Estimate your age in seconds. (MN 13-I) (LHR, FB, DG 14 I-II)

Ans: My age is 17 years old. So,

1 year = 365days
1 day = 24hours
1 hr = 60min
1 min = 60 sec

Total seconds in one year $= 365 \times 24 \times 60 \times 60$sec
$= 31536000$sec

Total secondsi n 17 years $= 17 \times 31536000$

My age is seconds = 536112000sec

1.4. Find the base quantities involved n each of the following derived quantities.
(a) Speed (b) Volume (c) Force (d) Work

Ans: **Speed:** Derived from "Length and time".
Volume: Derived from "Length".
Force: Derived from "Mass, length and time".
Work: Derived from "Mass, length and time".

1.5. What role Si units have playedin the development of science?(AK 14-II) (LHR 13-I) (BP 08-I) (GW 10-I)

Ans: Si units have brought consistency and uniformity in calculation and results. SI units are very helpful to exchange scientific and technical information at the international level.

1.6. What is meant by Vernier constant? (FB, MN, LHR 14-II) (SW, MN 13 I-II) (RWP 12-I) (GW 09-I, 10-I)

Ans: The least count of Vernier calipers is known as Vernier constant.
Vernier Constant: It is ratio between smallest reading on main scale to the total division on Vernier scale.

OR

The difference between one small division on main scale and one Vernier scale division.

Formula:

$$\text{Vernier constant} = \frac{\text{Smallest reading on main scale}}{\text{Total no.of divisions on vernier scale}}$$

1.7. Why is the use of zero error necessary in a measuring instrument? (LHR 13-I)

Ans: Zero error is necessary in measuring instrument to obtain an extreme correct value.

1.8. What do you understand by the zero error of a measuring instrument? (AK 14-I) (LHR 14-II) (LHR II-I) (GW 10-II)

Ans: When zero of Vernier scale does not coincide with zero of main scale, then instrument has “zero error”.

1.9. What is a stopwatch? What is the least count ofa mechanical stopwatch you have used in the laboratories? (RWP 13-I) (FB, BP 15-I) (GW 08-II) (GW 10-I)

Ans: **Stopwatch:**“Stopwatch is a device used to measure the time interval of an event”.

Least count: Mechanical stopwatches have least count up to 0.1 second.

1.10. What is meant by significant figures of a measurement? (AK, SW 14-I) (RWP 15-I) (BP II-I) (RWP 12-II)

Ans: **Significant figures:**“All the accurately known digits and the first doubtful digit in an expression are called significant figures”.

Significant figures reflects the precision ofa measure value of a physical quantity.

1.11. Why do we need to measure extremely small interval of times? (RWP 13-I) (BP 08-I) (AK 15-I)

Ans: We need to measure extremely small interval of times to calculate the time intervals of natural and artificial events. As in nature and also in phsyics, there are so many phenomenon which vary with respect to the small intervals of time.

1.12. How is precision related the the significant figures in a measured quantity? (SW, AK 14-I) (GW, RWP, SG 13-I-II)

Ans: An improvement in the quality of measurement by using better instrument increase the significant figures in the measured results. The significant figures are all accurately kwown digits and the one estimated digit.

Important Conversion

- 1MW = 10^6W
- 1kg = 10^3g
- 1 milligram = 10^{-3}g
- 1 micro gram = 10^{-6}g
- 1 nano gram = 10^{-9}g
- 1 pico gram = 10^{-12}g

- 1 day = 24 hrs
- 1 hr = 60 min
- 1 min = 60 sec
- 1 day = $24 \times 60 \times 60$
- 1 day = 86400 sec

Important Formulas

- $\text{L.C of S.G} = \frac{\text{Pitch}}{\text{noj.of division on circular scale}}$
- $\text{L.C of Vernier Calliper} = \frac{\text{smallest reading on main scale}}{\text{no.of divisions on vernier scale}}$
- Least count of Vernier caliper = 0.1mm or 0.01cm

- Least count of screw guage = 0.01mm or 0.001cm
- Area = Length × Width

Numericals

1.1. Express the following quantities using prefixes.
(a) 5000g (b) 2000000W (c) 52×10^{-10}kg (d) 225×10^{-8}S

Ans. Solution:

(a) 5000g
$= 5 \times 10^3$g $(\because 10^3\text{g} = 1\text{kg})$
= 5kg

(b) 2000000W
$= 2 \times 10^6$W $(\because 10^6\text{W} = 1\text{MW})$
= 2MW

(c) 52×10^{-10}kg
$= 52 \times 10^{-10} \times 10^3$g $(\because 1\text{kg} = 10^3\text{g})$
$= 52 \times 10^{-7}$g
$= 5.2 \times 10^1 \times 10^{-7}$g
$= 5.2 \times 10^{-6}$g $(\because 10^{-6}\text{g} = 1\mu\text{g})$

(d) 225×10^{-8}s
$= 2.25 \times 10^2 \times 10^{-8}$s
$= 2.25 \times 10^{-6}$s $(\because 10^{-6}\text{s} = 1\mu\text{s})$
$= 2.25\mu$s

1.2. How do their prefixes micro, nano and pico relate to each other?

Ans. Solution:

As
micro = 10^{-6}, nano = 10^{-9}, pico = 10^{-12}
So,
1000 nano = 1000×10^{-9}
$= 10^3 \times 10^{-9} = 10^{-6}$
1000 nano = 1 micro
Also,
1000 pico = 1000×10^{-12}
$= 10^3 \times 10^{-12} = 10^{-9}$
1000 pico = 1nano

1.3. Yoru hair grow at the rate of 1mm per day. Find their growth rate in nms^{-1}. (FB 15-I) (RWP, SW 15-II) (GW 08-I)

Ans. Solution:

Length of hair = 1m = 1×10^{-3}m
Time = 24 hr = 86400sec

To Find:
Growth rate per day = ?

Formula:

$$\text{Growth rate per day} = \frac{\text{Length of hair}}{\text{Time}}$$

Solution:

Putting the values, we have

$$\text{Growwht rate per day} = \frac{1\times10^{-3}\text{m}}{876400\text{sec}}$$

$= 1.157 \times 10^{-8}\text{ms}^{-1}$

$= 11.57 \times 10^{-9}\text{ms}^{-1}$

$= 11.57\text{nms}^{-1}$ $(\therefore 1\text{n} = 10^{-9})$

Result:

The growth rate per day of human hari is 11.57nms^{-1}.

1.4. Rewrite the following in standard form.

(a) 1168×10^{-27} **(b) 32×10^{5}**

(c) 725×10^{-5}kg **(d) 0.02×10^{-8}**

Ans. Solution:

(a) 1168×10^{-27}

$= 1.168 \times 10^{2}\times 10^{-27}$

$= 1.168 \times 10^{3-27}$

$= 1.168 \times 10^{-24}$

(b) 32×10^{5}

$= 3.2 \times 10^{1}\times 10^{5}$

$= 3.2 \times 10^{1+5}$

$= 3.2 \times 10^{6}$

(c) 725×10^{-5}kg

$= 7.25 \times 10^{2}\times 10^{-5}$kg

$= 7.25 \times 10^{2-5}$kg

$= 7.25 \times 10^{-3}$kg

$(\therefore \text{kg} = 10^{3}\text{g})$

$= 7.25 \times 10^{-3}\times 10^{3}$g

$= 7.25 \times 10^{-3+3}$g

= 7.25g

1.5. Write the following quantities in standard form.(FB 15-I) (SG 15-II) (GW 09-II)

(a) 6400km **(b) 380000km**

(c) 300000000ms^{-1} **(d) No. of second in a day**

Ans. Solution:

(a) 6400km

$= 6.4 \times 10^{3}$km

(b) 380000km

$= 3.8 \times 10^{5}$km

(c) 300000000ms^{-1}

$= 3.0 \times 10^{8}\text{ms}^{-1}$

(d) No. of seconds of a day

$= 24 \times 60 \times 60$s

$= 86400$s

$= 8.64 \times 10^{4}$s

1.6. One closing the jaws of Vernier caliper, zero the Vernier scale is on the right to its main scale such that 4th division of its Vernier scale coincides with one of the main scale division. Find its zero error and zero correction.

Ans. Solution:

Vernier division coinciding with main scale = 4th div.

Least count = 0.01 cm

Vernier scale reading = 4×0.01

= 0.04cm

Since zero of Vernier scale is on the right side of zero of the main scale, so, instrument has measured more than actual reading. It is positive zero error and correction should be negative.

Zero error = +0.04cm

Zero correction = -0.04cm

1.7. A screw gauge has 50 division on its circular scale. The pitch of the screw gauge is 0.5mm. What is the least count? (RWP 15-I)

Ans. Given data:

No.of divisions on circular scale = 50div.

Pitch of screw gauge = 0.5mm

To Find:

Least count =?

Soltuions:

$$\text{Least count} = \frac{\text{Pitch}}{\text{No.of division on circular scale}}$$

$$= \frac{0.5\text{mm}}{50} = 0.01\text{mm}$$

∴(1cm = 10mm)

Least count = 0.001cm

1.8. Which of the following quantities have three significant figures? (DG 14-II)

(a) 3.0066m **(b) 0.00309kg**

(c) 5.05×10^{-27}kg **(d) 301.0s**

Ans. Solution:

(a) 3.0066m has 5 significant digits.

(b) 0.00309kg has 3 significant digits.

(c) 5.05×10^{-27}g has 3 significant digits.

(d) 301.0s has 4 significant digits.

So, values in part (b) and (c) have three significant figures.

1.9. What are the significant figures in the following measurements?

(a) 1.009m **(b) 0.00450kg**

(c) 1.66×10^{-27}kg **(d) 2001s**

Ans. Solution:

(a) 1.009m has 4 significant digits.

(b) 0.00450kg has 3 significant digits.

(c) 1.66×10^{-27}kg has 3 significant digits.
(d) 2001s has 4 significant digits.

1.10. A chocolate wrapper is 6.7cm long and 5.4cm wide. Calculate its area up to reasonable number of significant figures.

Ans. Data:

Length of wrapper = 6.7cm
Width of wrapper = 5.4cm

Required:

Area of wrapper = ?

Solution:

Area = length × width
= 6.7cm × 5.4cm
= $36.18cm^2$

According to the principle of reasonable numbers of significant figures.

Area = $36cm^2$ (after rounding)

Chapter # 2 (Kinematics)

- **Choose the correct answer from the following choices:**

i. A body has translatory motion if it moves along a. (BP 14-I) (LHR 14-II) (RWP 08-I) (LHR 09-II)
(a)straight line (b) circle (c) line without rotation (d) curved path

ii. The motion of a body about an axis is called. (LHR 14-I) (LHR, GW 13 I-II) (DG, FB 1-II) (LHR 15-I) (MN, LHR, FB 15-II)
(a)circularmotion (b)rotatorty motion (c) vibratory motion (d) random motion

iii. Which of the following is a vector quantity? (SW 14-I) (MN, DG 13-II) (RWP 14-II) (LHR, FB 15-I) (LHR 15-II) (GW, LHR 08-I) (LHR 08-II)
(a)speed (b) distance (c) displacement (d) power

iv. If an object is moving with constant speed then its distance time graph will be a straight line.
(a)along time axis (b) along distance axis
(c)parallel to time axis (d) inclined to time axis

v. A straight line parallel to time axis on a distance time graph tells that the object is.
(a)moving with constant speed (b) at rest
(c)moving with variable speed (d) in motion

vi. The speed-time graph of a car is shown in the figures, when of the following statement is true?

Figure

(a) car has an acceleration of $1.5ms^{-2}$ (b) car has constant speed of $7.5ms^{-1}$
(c)distance travelled by the car is 75m (d) average speed of the car is $15ms^{-1}$

vii. Which one of the following graphs is representing uniform acceleration? (SW 14-II) (FB 13-I)

(a) (b)
(c) (d)

viii. By dividing displacement of a moving body with time, we obtain. (BP, LHR 14-I) (RWP, AK 13-II) (MN 14-II) (MN 15-I) (BP 08-I) (RWP 12-I)
(a)speed (b) acceleration (c) velocity (d) deceleration

ix. A ball is thrown vertically upward. Its velocity at the highest point is: (MN, LHR 14-I) (SG, LHR 14-II) (RWP 15-I)
(a) -10ms^{-1} (b) zero (c) 10ms^{-2} (d) none of these

x. A change in position is called. (MN 14-II) (SG, SW, FB 14-I) (MN, DG 13 I-II) (BP 15-II)
(a)speed (b) velocity (c) displacement (d) distance

xi. A train is moving at a speed of 36kmh^{-1}. Its speed expressed to ms^{-1} is: (MN 14-II) (S, GW 13-II) (FB 14-I) (BP 15-II) (FB 15-I)
(a) 10ms^{-1} (b) 20ms^{-1} (c) 25ms^{-1} (d) 30ms^{-1}

xii. A car starts from rest. It acquires a speed of 25ms^{-1} after 20s. The distance moved by the car during this time is: (RWP, SG, FB 14-II) (AK 13-I) (FB 14-II) (RWP 10-II) (RWP 12-I) (SW 15-I)
(a) 31.25m (b) 250m (c) 500m (d) 5000m

ANSWER:

i.	a.	**ii.**	b.	**iii.**	c.	**iv.**	c.	**v.**	a.
vi.	a.	**vii.**	a.	**viii.**	c.	**ix.**	b.	**x.**	d.
xi.	a.	**xii.**	c.						

Short Questions

• **Write short answers of the following questions:**

2.1. Explain translator motion and give exampels of varios types of translatorymotion. (GW, FB, RWP 13-I) (SW 14-II) (BP 15-I) (LHR 08-I) (RWP 12-I) (GW 10-II) (LHR 10-I)

Ans: Translatory motion: The mition in which a bdoy moves alogn a line (straight or curved) without any rotation, is called translator motion.

Example: Motion of ferris wheel.

Types of translator motion

(a) Circulat motion (b) Linear motion (c) Radnom motion

(a) Circular motion: The motion of an object in a circulat path is known as circular motion.

Example: A car moving along a circular track.

(b) Linear motion: Straight line motion of a body is known as its linear motion.

Example: Rocket flying straight in air is linear motion.

(c) Random motion: The disordered or irregular motion of an object is called random motion.

Example: Motion of insects and birds is random motion.

2.2. Define the terms speed, velocity and acceleration. (BP, AK 13-I) (FB 13-II) (FB 14-II) (LHR 15-II) (BP 15-I)

Ans: **Speed (V):** Rate of change of position with time is called speed. Its unit is ms^{-1}.

Velocity ($\vec{V}$): Rate of change of displacement is called velocity and its unit is ms^{-1}.

Acceleration ($\vec{a}$): Rate of change of velocity is called acceleration and its unit is ms^{-2}.

2.3. Differentiate between the following:

(a) Rest and motion.
(b) Circular motion and rotatory motion.
(c) Distance and displacement.
(d) Speed and velocity.
(e) Linear and random motion.
(f) Scalars and vectors.

Ans: **Rest and motion:**(SG 14-I) (SW, BP, SG, MN, FB 13 I-II) (BP II-II) (FB 15-I) (SW 08-II) (RWP 09-I) (LHR 12-I) (GW 12-II)

Rest	Motion
• "A condition in which a body does not change its position with respect to its surroundings".	• "A condition in which a body change its position with respect to its surroundings".

Circular Motion:(SW 14-I) (LHR, GW, AK, SW 13-I) (BP, LHR, AK 13-II) (MN, DG 14-I) (SG, FB, RWP 14-II) AK 15-I)

Circular motion	Rotatory motion
• Motion of an object or body in a circular path is called circular motion.	• The motion of a body around an axis passing through it is called rotatory motion.
• In circular motions, the point about which a body goes around is outside the body.	• In rotatory motion, the line around which a bdoy moves about is passing through the body itsef.

Distance and displacement:(SW 13-I) (GW 08-I) (FB, GW, MN 14 I-II) (FB, RWP 15-II)

Distance (s)	Displacement (d)
• Total length of a path between two points is called distance.	• The shortest distance between two points is called displacement.
• Distanceis a scalar quantity.	• Displacement is a vector quantity.

Speed and velocity:(SW, MN 13 I-II) (FB, SG, LHR DG 14 I-II) (LHR 13-II) (LHR 09-I) (FB, LHR 15-II) (BP 15-I) (BP 12-I)

Speed (V)	Velocity (V)
• Distance covered by a body in unit time is called speed.	• Rate of change of displacement is called velocity.
• Formula: $V = \frac{S}{t}$	• Formula: = $\vec{V} = \frac{\vec{d}}{t}$
• Speed is a scalar quantity.	• Velocity is a vector quantity.

Linear and random motion:(DG, FB, RWP 13-I) (LHR, AK 13-II) (SG, MN 14-II) (FB 14-I) (FB 15-I)

Linear motion	Random motion
• Motion of a body along a straight line is called linear motion.	• The irregular or zigzag motion of a body is called random motion.
Examples: Freely falling object.	**Examples:** Random motion of gas molecules.

Scalars and vectors:(LHR, GW, FB, AK, SW 13-II) (MN 13-I) (SW, LHR 14 I-II) (LHR 15-II) (FB 15-I) (GW, RWP 08-I) (LHR II-I) (GW 12-II)

Scalars	Vectors
• Scalar quantity is a quantity which can be completely specified by a magnitude only. **Example:** Work, power, speed, distance etc.	• Vectors are quantities, which are completely specified by both magnitude and direction. **Example:** Velocity, force, torque, displacement etc.

2.4. Can a body moving at a constant speed have acceleration? (AK 14-I) (MN, LHR 14-II) (DG 13-I)

Ans: Yes, a body moving at constant speed has acceleration if it changes it direction or moving in a circular path.

2.5. How do riders in a Ferries wheel possess translatory motion but not rotatory motion?

Ans: In rotatory motion, the line, about which a bdoy moves, its passing through the body itself. Here, riders in Ferris wheel have circular motion (a type of translatory motion) because the line about which wheel riders goes around, lies outside the body.

2.6. What would be the shape of a speed-time graph of a bdoy moving with variable speed?

Ans: The shape of velocity time graph is zigzag i.e. not a straight line, when the bdoy is moving variable speed.

2.7. Sketch a distance time graph for a body starting from rest. How will you determine the speed of a body from this graph? (LHR 13-I)

Ans: The shape of graph is as shown in fig.

Figure

The slope of this graph gives = $\frac{\Delta S}{t}$

$$= \frac{\text{change in distance}}{\text{time}} = \frac{d}{t}$$

i.e. slope of this graph = speed

2.8. Which of the following can be obtained from speed-time graph of a body? (AK, RP 13-II)

(a) Initial speed. (b) Final speed. (c) Distance covered in time t.

(d) Aceleration of motion.

Ans: All the above quantities can be obtained from speed-time graph of a moving body.

2.9. How can vector quantities be represented graphically? (SW 14-II) (GW, RWP, LHR 14-I) (LHR 09-II) (RWP 10-I)

Ans: Vectors are graphically represented by a straight line with an arrow head. The length of a line shows magnitude and arrow head tells about direction.

2.10. How are vector quantities important to us in our daily life?

Ans: Vectors quantities are important to us in our daily life because they provide complete information about quantity i.e. magnitude and direction.

2.11. Why vector quantities cannot be added and substracted like scalar quantities? (RWP, AK I-II) (DG, MN 13-I)

Ans: Scalars quantities are the quanaties which can be described completely by magnitude while vectors quantities need direction and magnitude for their complete description. The quantities having direction cannot be added and subtracted like scalar quantities.

2.12. Derive equations of motion for uniformly accelerated rectilinear motion. (SG, GW 14-II) (DG 13-I) (SG, RWP 15-II) (LHR 10-I) (GW 12-I) (LHR 08-II)

Ans: **(a)** $\mathbf{v_f = v_i + at}$

Slope of AB $= a = \frac{BC}{AC} = \frac{BD-CD}{OD}$

as BD $= v_f$, CD $= v_i$ and OD $= t$

$a = \frac{v_f - v_i}{t}$

$v_f = v_i + at$

(b) $\mathbf{S = v_i t + \frac{1}{2} at^2}$

From figure,

Area of OACD $= OA \times OD$

$= v_i \times t$

Area of triangle ABC $= \frac{1}{2} \times$ height $\times$ base

$= \frac{1}{2}$ (AC) (BC)

$= \frac{1}{2} at^2$

Total area OABD = Area of rectangle OACD + Area of triangle ABC

Total area $= vit + \frac{1}{2} at^2$

$S = vit + \frac{1}{2} at^2$

(c) $\mathbf{2aS = v_f^2 - v_i^2}$

Total area of OABD $= S = \left(\frac{OA+BD}{2}\right) \times OD$

Or $2S = (OA + BD)\ OD$

Multiplying by $\left(\frac{BC}{OD}\right)$ on both sides

$2S \times \left(\frac{BC}{OD}\right) = (OA + BD) \times (OD) \left(\frac{BC}{OD}\right)$

$2S \times \left(\frac{BC}{OD}\right) = (OA + BC) \times (BC)$

$2S \times a = (v_f + v_i)(v_f - v_i)$

$2aS = v_f^2 - v_i^2$

Important Formulas

- $v_f = v_i + at$
- $2aS = v_f^2 - v_i^2$
- $S = v_i t + \frac{1}{2} at^2$
- $S = v_{av} \times t$

Important Values

- 1km = 1000m
- 1hr = 3600sec
- $1kmh^{-1} = \frac{1000m}{3600sec}$
- $1m = \frac{11}{1000}km = \frac{1}{10^3}$ km
- $1m = 10^{-3}km = 0.001km$
- $1sec = \frac{1}{3600}$ h

$= \frac{10}{36}$ ms^{-1}

- **$1kmh^{-1} = 0.277ms^{-1}$**

- $1m/sec = \frac{0.001km}{1/3600 h}$
- $= 0.001 \times 3600km/h$
- **$1ms^{-1} = 3.6kmh^{-1}$**

Units: (S.I)

- Distance = S = metre (m)
- Displacement = d = metre (m)
- Speed = v = ms^{-1}
- Velocity = v = ms^{-1}
- Acceleration = a = ms^{-2}
- Time = t =s

Numericals

2.1. A train moves with a uniform velocity of $36kmh^{-1}$ for 10s. Find the distance travelled by it. (FB 15-II) (LHR 14-I) (SG, BP 13-II) (RWP 13-I) (DG 14-II) (GW, LHR 08-II)

Ans. Given data:

$V = 36kmh^{-1} = \frac{36 \times 1000}{3600}$

$= \frac{36000}{3600} = 10ms^{-1}$

$t = 10s$

To Find:

$S = ?$

Solution:

$S = V \times t$

$S = (10)(10)$

$\mathbf{S = 100m}$

2.2. A train starts from rest. It moves through 1km in 100s with uniform acceleration. What will be its speed at the end of 100s? (DG 14-II) (SW, RWP 13-I) (BP 15-I)

Ans. Given data:

$V_1 = 0ms^{-1}$

$S = 1km = 1000m$

$t = 100s$

To Find:

$V_f = ?$

Solution:

By using 2nd equation of motion.

$S = V_i t + \frac{1}{2} at^2$

$1000 = 0 \times t + \frac{1}{2}(a)(100)^2$

$1000 = \frac{1}{2}(a)(10000)$

$\frac{2000}{1000} = a$

$\mathbf{0.2ms^{-2} = a}$

Now, we can find the final velocity.

$v_f = vi + at$

Using the values.

$v_f = 0 + (0.2)(100$

$v_f = 20ms^{-1}$

The speed of the train is $20ms^{-1}$.

2.3. A car has velocity of $10ms^{-1}$. It accelerates at $0.2ms^{-2}$ for half minute. Find the distance travelled during this time and the final velocity of the car. (DG, LHR, BP 13-I) (GW 14-II) (RWP 09-I) (SW 15-II)

Ans. Given data:

$V_i = 10ms^{-1}$

$a = 0.2ms^{-2}$

$t = \frac{1}{2}$ minute = 30sec

To Find:

$S = ?$

$V_f = ?$

Solution:

(i) By using 2nd equation of motions.

$S = Vit + \frac{1}{2}at^2$

$S = (10)(10) + \frac{1}{2}(0.2)(30)^2$

$S = 300 + (0.1)(900)$

$= 300 + 90$

$\mathbf{S = 390m}$

(ii) Using 1st equation of motion

$V_f = V_i + at$

$V_f = 10 + (0.2)(30)$

$= 10 + 6$

$\mathbf{V_f = 16ms^{-1}}$

2.4. A tennis ball is hit vertically upward with a velocity of $30ms^{-1}$. It takes 3sec to reach the highest point. Calculate the maximum height reached by the ball. How long it will take to return to the ground? (GW 08-I) (FB 09-I)

Ans. Given data:

$V_i = 30ms^{-1}$

$V_f = 0ms^{-1}$

$g = -10ms^{-2}$

$t = 3sec$

To Find:

$S = h = ?$

Solution:

$h = v_it + \frac{1}{2}gt^2$

$h = (30) \times (3) + \frac{1}{2}(-10)(3)^2$

$h = 90 - 45$

$\mathbf{h = 45m}$

The time taken by the ball to come to the ground.

Data can be written in this case as,

Initial velocity = V_i = $0ms^{-1}$

Gravitational acceleration = g = $10ms^{-2}$

Time = t = ?

Distance = height = h = $45m$

As we know from second equation of motion.

$h = V_i t + \frac{1}{2}at^2$

By putting values, we get

$45m = (0)(t) + \frac{1}{2}(10)(t^2)$

$45m = 0 + 5t^2$

$\frac{45}{5} = t^2$

$t^2 = 9$

By taking under root on both side.

$\sqrt{t^2} = (3)^2$

$t = 3s$

Total time taken by the ball = 3 + 3 = 6s

2.5. A car moves with uniform velocity of $40ms^{-1}$ for 5s. It comes to rest in the next 10s with uniform deceleration. Find (i) the deceleration (ii) the total distance travelled by the car. (DG 15-I) (BP 12-I)

Ans. Given data:

Part (I)

Time = t = 10sec

Initial velocity = V_i = $40ms^{-1}$

Final velocity = V_f = $0ms^{-1}$

To Find:

Decelration = a = ?

Total distance covered = S = ?

Solution:

$V_f = V_i + at$

$0 = 40 + a(10)$

$-40 = 10s$

$\frac{-40}{10} = a$

$a = -4ms^{-2}$

Part (II)

To find the total distance (s)

$S = v \times t$

Using the values, we have.

$S = 40 \times 10$

$S = 400m$

The total distance covered by a car is 400m.

2.6. A train starts from rest with an acceleration of $0.5m/s^2$. Find its speed in km/h when it has moved through 100m.

Ans. Given data:

$V_i = 0ms^{-1}$

$a = 0.5ms^{-2}$

$S = 100m$

To Find:

$V_f = ?$

Using 3rd equation of motion.

Solution:

$2aS = v_f^2 - v_i^2$

$2 (0.5) (100) = v_f^2 - 0^2$

$v_f^2 = 100$

By taking square root on both sides

$V_f = 10ms^{-1}$

Conversion of ms^{-1} into Kmh^{-1}

$V_f = \frac{10 \times 3600}{1000} kmh^{-1}$

$V_f = 36kmh^{-1}$

2.7. A train starting from resat, accelerates uniformly and attains a velocity 48 km/h in 2 minutes. It travels at this spped for 5 minutes. Finally, it movswih uniform retardation and is stopped asfter 3 minutes. Find the total distance travelled by the train.

Ans. Given data:

$V_i = 0ms^{-1}$

$V_f = 48kmh^{-1}$

$= \frac{48 \times 100}{36000} ms^{-1}$

$= 13.3ms^{-1}$

$t_1 = 2min$

$= 2 \times 60 = 120s$

Required:

Total distance = S = ?

Solution:

$V_f = v_i + at$

$13.3 = 0 + a\,(120)$

$a = 0.1ms^{-2}$

i. Distance = S_1 = ?

$S_1 = V_it + \frac{1}{2}at^2$

$S_1 = 0 + \frac{1}{2}(0.1)(120)^2$

$\mathbf{S_1 = 800m}$

ii. Motion with constant velocity.

$V = 13.33ms^{-1}$

$t_2 = 5min = 5 \times 60 = 300s$

$S_2 = v \times t_2$

$S_2 = 13.33 \times 300$

$\mathbf{S_2 = 3999m}$

iii. Motion will negative acceleration.

$V_i = 13.33ms^{-1}$

$V_f = 0ms^{-1}$

$T_3 = 3min = 3 \times 60$

$T_3 = 180s$

$S_3 = V_{av} \times t_3$

$S_3 = \frac{V_i + V_f}{2} \times t_3$

$S_3 = \frac{13.33+0}{2} \times 180$

$\mathbf{S_3 = 1199.97m}$

Total distance = 800 m + 3999m + 1199.7m

Total distance = 6000m

2.8. A cricket ball is hit vertically upwards and returns to ground in 6s later. Calculate (i) the maximum height reached by the ball (ii) the initial velocity of the ball.

Ans. Given data:

Time taken by the ball to return to ground = 6s

Time to reach maximum height = $t = \frac{6}{2}$

$t = 3s$

$V_f = 0ms^{-1}$

To Find:

i. $S = h = ?$

ii. $V_i = ?$

Solution:

By using 1st equation of motion.

$V_f = V_i + at$

$V_i = V_f - at$

$V_f = 0 - gt$

$= 0 - (-10)(3)$

$V_i = 30msec^{-1}$

ii. Using 3rd equation of motion.

$2aS = v_f^2 - v_i^2$

$2(-10)h = (0)^2 - (300)^2$

$-20h = -(30)^2$

$-20h = -900$

$h = \frac{-900}{-20}$

$h = 45m$

2.9. When brakes are applied, the speed of a trin decreases from 96 kmh^{-1} to 48 kmh^{-1} in 800m. How much further will the train move before coming to rest? (BP 12-II) (SG 10-I)

Ans. Given data:

$V_i = 96kmh^{-1} = \frac{9 \times 1000ms^{-1}}{3600} = 26.67ms^{-1}$

$V_f = 48kmh^{-1} = \frac{48 \times 1000ms^{-1}}{3600} = 13.33ms^{-1}$

$S_1 = 800m$

To Find:

$S_2 = ?$

Using 3rd equation of motion

Solution:

The motion oftrain consist of two steps:

$2aS_1 = v_f^2 - v_i^2$

$a = \frac{v_f^2 - v_i^2}{2S_1}$

$a = \frac{(13.33)^2 - (26.67)^2}{2(800)}$

$a = -0.33ms^{-2}$

For 2nd step:

$V_i = 13.3ms^{-1}$

$V_f = 0ms^{-1}$

$a = -0.33ms^{-2}$

Distance covered $= S_2 = ?$

Using 3rd equation of motion.

$2aS_2 = v_f^2 - v_i^2$

$S_2 = \frac{v_f^2 - v_i^2}{2a}$

$S_2 = \frac{(0)^2 (13.3)^2}{2(-0.33)}$

$S_2 = 266.6m$

2.10. In the above problem. Find the time taken by the train to stop after the application of brakes.

Ans. Given data:

$V_i = 26.67ms^{-1}$

$V_f = 0ms^{-1}$

$a = -0.33ms^{-2}$

To Find:

$t = ?$

Using 1st equation of motion.

Solutiuon:

$V_f = V_i + at$

$t = \frac{V_f - V_i}{a}$

$t = \frac{0 - 26.67}{-0.33}$

$\mathbf{t = 80.1s}$

Chapter # 3 (Dynamics)

- **Choose the correct answer from the following choices:**

i. Newton's first law of motion is valid only in the absence of: (LHR 14-I) (RWP 14-II) (BP 09-II) (LHR 10-I) (GW 09-I) (LHR 08-I) (RWP 12-I) (BP, LHR 15-I) (LHR 15-II)

(a)force (b)net force (c) friction (d) momentum

ii. Inertia depends upon: (MN 14-I) (SG, MN, GW, FB 13 I-II) (LHR, GW, FB 14-II) (GW, LHR 10-I) (RWP 09-I) (RWP 15-II)

(a)force (b) net force (c) mass (d) velocity

iii. A boy jumps out of a moving bus. There is a danger for him to fall: (RWP 15-I) (FB 15-II)

(a)towards the moving bus (b) away for the bus
(c)in the direction of motion (d) opposite to the direction of motion

iv. A string is stretched by two equal and opposite forces 10N each. The tension in the string is: (SW 14-I) (GW, LHR 13 I-II) (LHR 12-I)

(a)zero (b) 5N (c) 10N (d) 20N

v. The mass of a body: (SG 14-II) (MN 15-I)

(a)decrease when accelerated (b) increases when accelerated
(c)dereases when moving with high velocity (d) none of the above

vi. Two bodies of masses m_1 and m_2 attached to the ends of an inextensible string passing over a frictionless pulling such that both move vertically. The acceleration of the bodies is: (SG 14-II) (AK, BP 13 I-II) (AK 15-I) (SG 15-II) (SW 08-II)

(a)$\frac{m_1 \times m_2}{m_1 \times m_2}g$ (b)$\frac{m_1 - m_2}{m_1 + m_2}g$ (c)$\frac{m_1 + m_2}{m_1 - m_2}g$ (d)$\frac{2m_1m_2}{m_1 + m_2}g$

vii. Which of the following is the unit of momentum? (GW, DG, RWP, LHR 13-II) (SW, FB 14-I) (MN 13-I) (DG 14 I-II) (AK II-I) (LHR 09-II) (SG 15-I)

(a) Nm (b) $kgms^{-2}$ (c) Ns (d) Ns^{-1}

viii. When horse pulls a cart, the action is on her: (MN 14-II) (SG, LHR 14-I) (GW, LHR 10-I)

(a) cart (b) Earth (c) horse (d) Earth and cart

ix. **Which of the following material lowers friction when pushed between metal plates?** (LHR 10-I) (FB 14-I) (LHR 14-II) (GW 08-I) (RWP, LHR 15-I) (MN, LHR 15-II)

(a)water (b) fine marble powder (c) air (d) oil

ANSWER:

i.	b.	ii.	c.	iii.	c.	iv.	c.	v.	d.
vi.	b.	vii.	c.	viii.	d.	ix.	d.		

Short Questions

- **Write short answers of the following questions:**

3.1. Define the following terms: (AK, SW 13-I) (DG, MN, FB 14-I) (GW 08-I) (BP 10-I, 15-I) (FB 15-II)

(a)Inertia (b) Momentum (c) Force

(d) Force of friction (e) Centripetal force

Ans: **Inertia:**(AK, SW 13-I) (DG, MN, FB 14-I) (GW 08-I) (BP 10-I, 15-I) (FB 15-II)

Inertia of a body is its property due to which is resists any change in its state of rest or motion.

Momentum:(MN 13-I) (DG, SG, LHR 14-II) (LHR 15-I) (AK 08-I)

Momentum of a body is the quanatiy of motion possessedby the body. Momentum of a bdoy is equal to the prduct of its mass and velocity.

Formula: P = mv

Unit: Ns or kgms^{-1}.

Force:(AK, SW, FB 14-II) (LHR 09-I) (FB 15-II) (RWP, FB, BP 15-I)

A forceis push or pul. It moves or tends to move, stops or tends to stop the motion of a body. The force can also change the direction of motion of a body.

Unit: Its SI unit is kgms^{-2}.

Force of friction:(FB 14-II)

The force that opposes the motion of moving objects is called friction.

Centripetal force:(BP, SG 14-I-II) (RWP, LHR, BP 15-I)

The force which keeps the body to move in a circular path is called the centripetal force.

$$F_c = \frac{mv^2}{r}$$

3.2. What is the law of intertia? (LHR, FB, MN 14-I) (MN 14-II) (SG, SW 13-II)

Ans: **Law of inertia:** Newton's first law of motion deals with the inertial property of matter, so *Newton's first law of motion is also known as law of inertia*.

Statement: "A body continues its state of rest or of uniform motion in a straight lien provided no net force acts on it".

3.3. What is the difference between: (DG, AK, BP 13-I)

(a) Mass and weight

(b) Action and reaction

(c) Sliding friction and rolling friction

Ans: **Mass and weight:**(LHR, MN 14-II) (SG 14-I) (LHR 15-I)

Mass (m)	Weight (w)

Mass	Weight
• Mass of a body is the quantity of matter that it possesses. • Mass is a scalar quanatity.	• Weight of the body is equal to the force with which Earth attracts it. • Weight is a vector quantity.

Action and rreaction:(RWP 13-I) (SW 08-I, 15-I) (BP 09-I)

Action	Reaction
• It is a force that is exerted by body on other body. **Example:** Let force of **A** on the other body **B** is called action force.	• It is also a force which is exerted by the other body on first one. **Example:** Let force of **B** on the first body **A** is called reaction force.

Sliding friction and rolling friction:(SW 14-II) (RWP, FB 15-II) (SW 12-I)

Sliding friction	Rolling friction
• A force between the sliding objects which opposes the relative motion between them is called sliding friction.	• Rolling friction is the force of friction between a rolling body and the surface over which it rolls.

3.4. Why is it dangerous to travel on the roof of a bus? (AK 10-I) (RWP 09-I) (SW 12-I)

Ans: If a person travels on the roof of a bus, it would be dangerous because when a bus takes a sharp turn, passengers fall in the outward direction. It is due to inertia that they want to continue their motion in a straight line and thus fall outwards.

3.5. How can you relate a force with the change of momentum of a body? (FB, AK 14-I) (MN, RWP 14-II) (FB, LHR, BP 15-I) (SW 09-I)

Ans: When a force acts a body. It produces acceleration in the bodyand will be equal to the rate of change of momentum of the body. We can write it as:

Change in momentum = final momentum – initial momentum

$$P_f – P_i – mv_f – mv_i$$

Thus, rate of change in momentum is given by:

As,

So,

And Newton's second law of motion tells us that

$$F = ma$$

By putting the value of F in eq. (i)

$$\frac{P_f - P_i}{t} = F$$ **Hence proved**

3.6. Why does a passenger move outward when a bus takes a turn? (SW 10-I) (BP 12-I) (GW 09-I)

Ans: When a bus takes a sharp turn, pasengers fall in the outward direction. It is due to inertia that they want to continue their motion in a straight line and thus fall outwards.

3.7. What will be the tension in a rope that is pulled from its ends by two opposite forces 100N each?(SW 14-I) (MN 15-I) (AK 09-II)

Ans: When two forces of 100N, each are applied on a string, then the resultant tension is 100N.

3.8. A horse pulls that cart. If the action and reaction are equal and opposite then how does the cart move? (GW 12-I) (LHR 09-II)

Ans: The horse applies action by feet on the road, the reaction is given by road on horse, due to which horse moves. The cart, which is tied with the horse, also moves. Since, action and reaction never acts on same body, so the cart moves.

3.9. Aaction and reaction are always equal and opposite. Then how does a body moves? (SW 14-I) (SW 15-I) (LHR 10-I) (GW 10-II)

Ans: According to *Newton's third law of motion, action and reaction are always equal and opposite in direction.* But action and reaction forces always act on different bodies, so they do not cancel the effect of each other, and under the conition of forces the body moves irrespective to this, that action and reaction are equal but opposite in direction.

3.10. What is the law of conservation of momentum? (MN,BP 13-I) (BP 14-II) (MN 14-I) (RWP 12-I) (FB, RWP 15-II)

Ans: **Law of conservation of momentum:** "The momentum of an isolated system of two or more than two interacting bodies remains constant."

Examples: Firiing a bullet, release of air from balloon.

3.11. When a gun is fired, it recoils. Why?(BP 14-I) (RWP 14-II) (MN 13-I) (FB 15-I)

Ans: As the gun is fired, bullet shoots out of the gun and acquires some momentum. To conserve the momentum of the system, the gun recoils.

3.12. Why is the law of conervation of momentum important? (BP, RWP 09-I) (LHR 12-I)

Ans: By using law of conservation of momentum, it is possible to calculate force, velocity, and acceleration of a body. Most of elementary particles are discovered by the use of this law.

3.13. Describe two situations in which force of friction is needed. (FB 15-I) (BP II-I)

Ans: There are many conditions in which friction is desirable; two of them are given below:

i. Friction is needed when we write.

ii. Friction enables us to wal on the ground.

3.14. Describe ways to reduce friction. (BP II-I) (BP, MN 14-I) (LHR, FB 14-II) (SW, AK, SG 13-II) (LHR, MN 13 I-II) (RWP 12-I, 15-II)

Ans: **Method of reducing friction:**

i. Using grease or any other lubricant.

ii. Using smoother surfaces.

iii. Using rollers, wheels or ball bearings.

iv. Objects like car and planes are modeled with streamlined shapes.

3.15. How does oiling the moving parts of a machine lowers friction? (SG 12-I)

Ans: Oiling the moving parts of a machine lowers friction because the oil fills up all the rough spot (cold welds) and make the surface smooth.

3.16. Why roiling friction is less than sliding friction? (LHR, SW, DG 14-II) (LHR 13-I) (BP, DG 14-I)

Ans: "Rolling friction is much less than sliding friction because in case of rolling friction contact area (cold welds points) of the two surfaces is very small as compared to sliding friction."

3.17. What you know about the following:

(a) Tension in a string
(b) Limiting force of friction
(c) Braking force
(d) Skidding of vehicles
(e) Seatbelts
(f) Banking of roads
(g) Cream separator

Ans: **Tension in a string:** The force acting along a string causes tension in the string.

Limitting force of friction: The frictional force that exists between the surfaces of two stationary bodies in contact with each other.

Braking force: It is a meaure of braking power of a vehicle.

Skidding of vehicles: The act of sliding or slipping of a vehicle over a surface, often sideways without revolving.

Seatbelts: A belt or strap in an automobile, or airplanes to hold you in your seat in case of an accident or sudden stop.

Banking of roads:(BP 14-I) (RWP, LHR 13-II) (BP, RWP 14-II) (SW 15-I)

The phenomenon of raising outer edge of the curved road above the inner edge is to provide necessaryccentripetal force to the vehicle to take safer turn on the curve road is called banking of roads.

Cream separator:(RWP 14-I) (RWP 14-II)

A device which is used to separate cream from milk.

3.18. What would happen if all friction suddenly disappears?

Ans: If there was no friction then we could not walk, we would keep sliping. Nothing would steady on ground and nothing wouldexist in the way they do now.

3.19. Why the spinner of a washing machine is made to spin at a very high speed?

Ans: Spinner of a washing machine is made to spin at a very high speed. Because when it spins at high speed, the water from wet clothes is forces out through these holes **due to lack of centripetal force**.

Important Formulas

- $F = ma$
- $F = \frac{\Delta P}{t}$
- $F_c = \frac{mV^2}{r}$

If both masses are suspended vertically.

- $T = \left(\frac{2m_1m_2}{m_1+m_2}\right)g$
- $a = \left(\frac{m_1-m_2}{m_1+m_2}\right)g$

- $W = mg$
- $F_s = \mu_s R = \mu_s mg$

If one mass is horizontal and other is suspended vertically.

- $T = \left(\frac{m_1m_2}{m_1+m_2}\right)g$
- $a = \left(\frac{m_1 g}{m_1+m_2}\right)$

- Unit of tension = Newton
- Unit of acceleration = ms^{-2}

Numericals

3.1. A force of 20N moves a body with an acceleration of 2ms^{-2}, what is its mass? (GW 13-II) (LHR 13-I)

Ans. Given data:

F = 20N

$a = 2ms^{-2}$

To Find:

$m = ?$

Solution:

By using Newton's second law of motion.

$F = ma$

$m = \frac{20}{2}$

$\mathbf{m = 10kg}$

3.2. The weight of a body is 147. What is its mass? (Take the value of g as $10ms^{-2}$). (AK, LHR, RWP 13 I-II)

Ans. Given data:

$w = 147N$

$g = 10ms^{-2}$

To Find:

$m = ?$

Solution:

We know that

$w = mg$

$m = \frac{w}{g}$

$m = \frac{147}{10}$

$\mathbf{m = 14.7kg}$

3.3. How much force is needed to prevent a bdoy of mass 10kg from falling? (AK 14-I) (RWP 15-I) (BP II-I)

Ans. Given data:

$m = 10kg$

$g = 10ms^{-2}$

To Find:

$F = ?$

Solution:

$F = mg$

$= (10)(10)$

$\mathbf{F = 100N}$

3.4. Find the acceleration produced by a force of 100N in a mass of 50kg. (GW 14-I, II) (BP, SW 13-I-II) (RWP, FB 15-II)

Ans. Given data:

$F = 100N$

$m = 50kg$

To Find:

$a = ?$

Solution:

Using Newton's second law of motion.

$F = ma$

Also $a = \frac{F}{m}$

$a = \frac{100}{50}$

$\mathbf{a = 2ms^{-2}}$

3.5. A body has weight 20N. How much force is required to move it vertically upwards with an acceleration of $2ms^{-2}$? (FB, GW 13-I)

Ans. Given data:

$w = 20N$

$a = 2ms^{-2}$

To Find:

Force = F = ?

Solution:

$w = mg$

$m = \frac{w}{g}$

$= \frac{20}{10}$

$m = 2kg$

Using Newton's 2nd law of motion

$F = ma$

$F = (2)(2) = 4N$

Force required to move the body vertically upwards = W + F

= 20 + 4 = 24N

3.6. Two masses 52kg and 48 kg are attached to the ends of string that passes over a frictionless pulley. Find the tension in the string and acceleration in the bodies, when both masses are moving vertically.

Ans. Given data:

$m_1 = 52kg$

$m_2 = 48kg$

$g = 10ms^{-2}$

To Find:

$T = ?$

$a = ?$

Solution:

We know that

$T = \frac{2m_1m_2g}{m_1+m_2}$

$$T = \frac{2 \times 52 \times 48 \times 10}{52+48}$$

$$= 499.2N$$

$$T = 500N \text{ (approximately)}$$

Now for acceleration,

$$a = \frac{(m_1+m_2)}{m_1 m_2} g$$

$$a = \frac{(52-48)}{(52+48)} \times 10$$

$$= \frac{4(10)}{100}$$

$$\mathbf{a = 0.4ms^{-2}}$$

3.7. Two masses 26kg and 24kg are attached to the ends of string which passes over a frictionless pulley. 26kg is lying over a smooth horizontal table. 24N mass is moving vertically downward. Find the tension in the string and the acceleration in the bodies.

Ans. Givne data:

m_1 = 24kg

m_2 = 26kg

g = $10ms^{-2}$

We know

$$T = \frac{m_1 m_2 g}{m_1+m_2}$$

$$T = \frac{(24)(26)(10)}{24+26} = \frac{6240}{50}$$

$$T = 124.8$$

$$\mathbf{T = 125N}$$

Now

Using formula for a.

$$a = \frac{m_1 g}{m_1+m_2}$$

$$a = \frac{(24)(10)}{24+26}$$

$$\mathbf{a = 4.8ms^{-2}}$$

3.8. How much time is required to change 22Ns momentum by a force of 20N?

Ans. Given data:

Change in momentum = ΔP = 22Ns

F = 20N

To Find:

t = ?

Solution:

We know that rate of change of momentum is equal to force acting on it.

$$F = \frac{\Delta P}{t}$$

$$t = \frac{\Delta P}{F}$$

$$t = \frac{22}{20}$$

t = 1.1s

3.9. How much is the force of friction between a wooden block of mass 5kg and the horizontal marble floor? The coefficient of friction between wood and marble is 0.6. (RWP 13-II) (AK 14-I) (FB 15-II)

Ans. Given data:

m = 5kg

μ_s = 0.6

g = $10ms^{-2}$

To Find:

Force of friction = F = ?

Solution:

By using formula.

F = $\mu_s R$

F = $\mu_s mg$

∴R = mg

F = (0.6) (5) (10)

F = 30N

3.10. How much centripetal force is needed to make a body of mass 0.5kg to move in a circle of radius 50cm with a speed $3ms^{-1}$? (LHR 13-I)

Ans. Given data:

m = 0.5kg

r = 50cm = $\frac{50}{100}$m = 0.5m

v = $3ms^{-1}$

To Find:

F_c = ?

Solution:

By using formula:

$F_c = \frac{mv^2}{r}$

$F_c = \frac{(0.5)(3)^2}{(0.5)}$

F_c = 9N

Chapter # 4 (Turning effect of forces)

- **Choose the correct answer from the following choices:**

i. **Two equal but unlike parallel forces having different line of action produce.** (AK 12-I)
(a)a torque (b) a couple (c) equilibrium (d) neutral equilibrium

ii. **The numbr of forces that can be added by head to tail rule are:** (MN 13-II) (LHR 10-I) (GW, SG, BP 12-I) (GW 08-I) (BP 15-I)
(a) 2 (b) 3 (c) 4 (d) any number

iii. **The Number of perpendicular components of a force are:** (LHR, RWP 13-I-II) (GW, FB 14-II) (LHR 12-I) (SG 15-II) (SW 10-I)
(a) 1 (b) 2 (c) 3 (d) 4

iv. **A force of 10N is making an angle of 30o with the horizontal. Its horizontal component will be:** (SW, LHR 13-I-II) (GW, LHR, AK, RWP 13-I) (FB 14-II) (RWP 09-I) (SG 08-I) (SW 12-I) (BP II-I) (RWP 15-I) (RWP 15-II)
(a) 4N (b) 5N (c) 7N (d) 8.7N

v. **A couple is formed by:** (SG 14-II) (MN 13-I) (LHR II-II) (LHR 12-I) (GW 08-I) (RWP 15-I)
(a)two forces perpendicular to each other (b) two like parallel forces
(c)two equal and opposite force in the sameline
(d)two equal and opposite forces not in the sameline

vi. **A body is in equilibrium when its:** (SG, MN 14-II) (LHR II-II) (GW, SG, LHR 08-I) (SG 13-II)
(a)acceleration is uniform (b) speed is uniform
(c)speed and acceleration are uniform (d) acceleration is zero

vii. **A body is neutral equilibrium when its centre of gravity:** (FB 14-II) (RWP 14-II) (LHR 12-I) (RWP 09-II) (SG 08-II)
(a)is at its highest position (b) is at the lowest position
(c)keeps its height if displaced (d) is situated at its bottom

viii. **Racing cars are made stable by:** (BP 14-I) (SW, MN 14-II) (DG, FB 13-II) (DG, FB, GW 14-I-II) (AK 15-I) (FB, SG 15-II)
(a) increasing their speed (b) decreasing their mass
(c)lowering their centre of gravity (d) decreasing their width

ANSWER:

i.	b.	ii.	d.	iii.	b.	iv.	d.	v.	d.
vi.	b.	vii.	c.	viii.	c.				

Short Questions

- **Write short answers of the following questions:**

4.1. **Define the following:** (BP, FB 14-I-II) (LHR, SW, DG, AK 14-I)
(a) resultant vector **(b) torque**
(c) centre of mass **(d) centre of gravity**

Ans: **Resultant vector:**(LHR 13-I) (GW 13-II) (LHR II-I) (LHR 09-II) (GW 08-I) (SG, GW 12-I)
A resultant vector is a single vector that has the same effect as the combined effect of all the vectors to be added.

Torque:(AK 14-I) (FB, LHR 13-I-II) (SW, FB, MN, DG 14-I-II) (BP 15-I) (BP, SG 08-I) (SW 09-I) (LHR 12-I)
The tuning effect of a force is called torque or moment of the force.

Symbol: τ

Formula: $\tau = r \times f$

Units: Newton metre (Nm)

Centre of mass: (AK 14-I) (LHR 14-II) (RWP 13-I-II) (FB 15-II) (BP 15-I) (LHR 08-I, 09-I) (LHR, BP, GW 12-I)

Centre of mass of a system is such a point where an applied force causes the system to move without rotation.

Centre of gravity: (LHR, SW, SG 14-II) (LHR, BP 14-I) (LHR 13-II) (GW, SG, SW 09-I) (BP II-I) (RWP 15-II) (FB, AK 15-I)

The centre of gravity of a body is defined as point where the whole weight of the body appears to act vertically downward.

4.2. How head to tail rule helps to find the resultant of forces? (BP, MN 14-I) (SW, BP 13-I-II) (FB 14-II) (FB, LHR 12-I) (FB 08-II) (GW II-I) (LHR 09-I) (FB, RWP 15-I)

Ans: **Head to tail rule:** The vectors are added graphically suhch that tial of 2nd vector coincides with headof 1st vector and so on. The resultant of all vector is obtained by coinciding the tail of 1st vector to head of last vector.

The resultant of two forces can be found by using the method for adding vectors when the vectors are geometric represaentation.

4.3. When a body is said to be in equilibrium? (MN 14-II) (FB 15-II) (FB 12-I) (SG 09-I)

Ans: A body is said to be in equilibrium if it satisfies both conditions of equilibrium.

i. A body is in equilibrium if net force acting on it is zero.

$$\Sigma F = 0, \text{ or } \Sigma F_y = 0, \Sigma F_x = 0$$

ii. A body is said to be in equilibrium if the resultant torque acting on it is zero.

$$\Sigma \tau = 0$$

4.4. How can a force be resolved into its rectangular components? (BP II-I) (BP 15-II) (LHR 08-I)

Ans: **Resolution of a vector**: When a given vector is drawn graphically then it may split up into two parts which are perpendicular to each other. Then each of these two parts of a vector is called the rectangular component. Through this figure it is shown that the rectangular components which are OB = F_x and AB = F_y.

Figure

4.5. Differentiate the following:

(a) like and unlike parallel forces **(b) torque and couple**

(c)stable and neutral equilibrium

Ans: **Like and unlike parallel forces:** (SW, LHR, SG 14-II) (RWP 14-I) (GW, RWP 13-I) (FB 15-II) (LHR 15-I) (FB, GW, SW II-II) (LHR 09-I) (AK 08-I)

Like parallel forces	Unlike parallel forces
• If two parallel forces act in same direction then they are called like parallel forces.	• If two parallel forces asct in opposite direction they they are called unlike parallel forces.

Torque and couple:(SG, DG, LHR 14-I) (FB 14-II) (RWP 13-I, II) (LHR II-I) (GW 09-II) (RWP 08-II) (SG 09-I) (SW 10-12-I) (RWP, BP 15-II)

Torque	Couple
• The turning effect of a force is called torque.	• A couple is formed by two unlike parallelforces of same magnitude but not along same line.
• Torque is produced under the action of only one force.	• Couple is produced under action of two unlike parallel forces.

Stabel and neutral equilibrium:(SW, LHR, SG 14-II) (RWP 14-I) (GW, RWP 13-I) (FB 15-II) (LHR 15-I) (FB, GW, SW II-II) (LHR 09-I) (AK 08-I)

Stabel equilibrium	Neutral equilibrium
• In stable equilibrium centre of mass of a body lies at lowest position.	• In neutral equilibrium, the centre of gravity lies at same height.

4.6. Explain the first condition for equilibrium.(DG 13-I) (MN 14-I) (FB 15-I) (RWP 15-II) (SW 09-I) (GW II-I)

Ans: **First condition for equilibrium:**"A body is said to satisfy first condition for equilibrium if the resultanat of all the forces acting on it is zero".

$$\Sigma F = 0$$

i.e. $\Sigma F_x = 0$

$$\Sigma F_y = 0$$

4.7. What is second condition for equilibrium? (AKM, BP, FB, BP, MN 13-I-II) (SG, BPM, RWP, AK 14-I-II) (MN, SW 15-I) (MN 15-II) (MN 08-I)

Ans: **Second condition fot equilibrium:**"A body satisfies second condition for equilibrium when the resultant torque acting on it is zero".

Mathematically:$\Sigma\tau = 0$

4.8. Why there is a need of second condition for equilibrium if a body satisfies first condition for equilibrium? (BP 12-I)

Ans: **Reason:** Two equal and opposite forces having different line of action form couple, which produces angular acceleration. Although, first condition for equilibrium is satisfied but still in this case, object need to satisfy second condition to ensure equilibrium state.

4.9. Give an example of a moving body which is in equilibrium. (BP II-I) (BP 09-II) (RWP 12-I)

Ans: A paratrooper coming down with terminal velocity (constant velocity) is in equilibrium as all the forces acting on it is equal to zero, which satisfies the first condition for equilibrium.

4.10. Why a body cannot be in equilibrium due to single force acting on it? (BP 14-II) (MN 13-I) (LHR 15-I) (SG, SW 15-II)

Ans: Single force acting on a body is not balanced and produced acceleration. Therefore under influence of single force, a body cannot be in equilibrium.

4.11. Think of a body which is at rest but not in equilibrium. (RWP 12-II) (GW 09-II)

Ans: A body thrown upward is at rest just for a while at highest point. But force of gravity still acts on it to produce acceleration. Thus, the body is at rest but not in equilibrium.

4.12. Why the height of vehicles is kept as low as possible? (FB, SG 14-I) (RWP, SW, LHR 14-I-II) (LHR 08-II) (GW 09-II)

Ans: Vehicles are made heavy at the bottom and their height is kewpt to be minimum. This lowers their centre of gravity and helps to increase their stability. As to make them stable, their centre of mass must be kept as low as possible.

4.13. Explain what is meant by stable, unstable and neutral equilibrium. Give one example in each case. (MN 14-I) (SW 13-II) (RWP 15-I) (MN 12-I)

Ans: **Stable equilibrium:** Equilibrium is considered stable if after a slight tilt, it returns to its previous positions.

Example: A book lying on a table.

Unstable equilibrium: If a body does not return to its previous position when sets free after a slight tilt, then the equilibrium is unstable.

Example: A pencil standing on its point.

Neutral equilibrium:(AK 14-I)

If a body remains in its new positions when disturbed from its previous position, it is said to be in neutral equilibrium.

Example: Rolling Ball.

Important Conversion

- Magnitude = F = $\sqrt{F_x^2 + F_y^2}$
- Direction = 0 = $\tan^{-1}\left(\frac{F_y}{F_x}\right)$
- Torque = $\tau = r \times F$
- Conditions of equilibrium

i.$\Sigma\vec{F} = 0$ i.e. Fx = 0, Fy = 0

ii.$\Sigma\tau = 0$ i.e. $\tau_1 = \tau_2$

- $F_x = F\cos\theta$
- $F_y = F\sin\theta$

Numericals

4.1. Find the resultant of the following forces:

(a) 10N along x-axis **(b) 6N along y-axis**

(c) 4N along negative x-axis

(BP 13-II) (AK 13-I) (BP 09-I) (LHR 08-I) (SG 15-I)

Ans. Given data:

F_1 = 10N along x – axis

F_2 = 6N along y – axis

F_3 = 4N along negative x – axis

To Find:

Resultant force = F = ?

Solution:

F_1 = 10N (along x – axis)

F_3 = 4 N (along negative x – axis)

Now

F_1+F_2 = 10 – 4

F_4 = 6N

And F_2 = 6N

Since F_2 and F_4 are perpendicular to each other,
By using formula

$$F = \sqrt{(F_2)^2 + (F_4)^2}$$
$$= \sqrt{(6)^2 + (6)^2}$$
$$= \sqrt{36 + 36}$$
$$= \sqrt{72}$$
$$F = 8.4N \approx 8.5N$$
$$Tan\theta = \frac{F_y}{F_x} = \frac{F_2}{F_4} = \frac{6}{6}$$
$$Tan\theta = 1$$
$$\theta = tan^{-1}(1)$$
$$\boldsymbol{\theta = 45^o}$$

The angle will be 45^o along x – axis.

4.2. Find the rectangular components of a force of 50N making an angle of 30o with x – axis. (FB 08-I) (RWP 10-I) (FB 15-I)

Ans. Given data:

$F = 50N$
$\theta = 30^o$

To Find:

$F_x = ?$
$F_y = ?$

Solution:

$$F_x = F\cos\theta$$
$$= 50 \times \cos30^o$$
$$= 50 \times 0.866$$
$$\boldsymbol{F_x = 43.3N}$$

Also $F_y = F\sin\theta$
$$= 50 \times \sin30^o$$
$$= 50 \times 0.5$$
$$\boldsymbol{F_y = 25N}$$

4.3. Find the magnitude and direction of a force if its x-component is 12N and y-component is 5N. (RWP 09-I) (RWP 12-I) (GW 12-II)

Ans. Given data:

$F_x = 12N$
$F_y = 5N$

To Find:

$F = ?$
$\theta = ?$

Solution:

$$F = \sqrt{(F_x)^2 + (F_y)^2}$$
$$= \sqrt{(12)^2 + (5)^2}$$

$= \sqrt{144 + 25}$

$= \sqrt{169}$

$F = 13N$

Now,

$\text{Tan}\theta = \frac{F_y}{F_x}$

$\theta = \tan^{-1}\frac{F_y}{F_x}$

$\theta = \tan^{-1}\frac{5}{12}$

$\theta = \tan^{-1}(0.41)$

$\boldsymbol{\theta} = \mathbf{22.6^o}$ **with x-axis**

4.4. A force of 100N is applied perpendicularly on a spanner at a distance of 10cm from a nut. Find the torque produced by the force. (GW 14-I) (GW 13-I)

Ans. Given data:

$F = 100N$

$r = 10cm = \frac{10}{100} m = 0.1m$

To Find:

$\tau = ?$

Solution:

$\tau = r \times F$

$\tau = 0.1 \times 100$

$\boldsymbol{\tau} = \mathbf{10Nm}$

4.5. A force is acting on a body making an angle of 30º with the horizontal. The horizontal component of the force is 20N. Find the force. (SG 08-I)

Ans. Given data:

$\theta = 30^o$

$F_x = 20N$

To Find:

$F = ?$

Solution:

As we know that

$F_x = F\cos\theta$

$20 = F\cos 30^o$

$\frac{20}{\cos 30^o} = F$

$F = \frac{20}{0.866}$

$F = 23.09N$

$\mathbf{F = 23.1N}$

4.6. The steering of a car has radius 16cm. Find the torque produced by a couple of 50N. (LHR 15-I) (RWP 15-II)

Ans. Given data:

$F = 50N$

r = 16cm = $\frac{16}{100}$ m

= 0.16m

Perpendicular distance between forces

= 0.16 + 0.16

= 0.32m

To Find:

τ = ?

Solution:

τ = Force × Perpendicular distance between forces

τ = 50 × 0.32

$\boldsymbol{\tau}$ **= 16Nm**

4.7. A picture frame is hanging by two vertical strings. The tensions in the springs are 3.8N and 4.4N. Find the weight of the picture frame. (FB 12-II)

Ans. Given data:

T_1 = 3.8N

T_2 = 4.4N

To Find:

Weight = W = ?

Solution:

As picture frame is in equilibrium.

$\Sigma F_x = 0, \quad \Sigma F_y = 0$

Therefore

$T - W = 0$

$(T_1 + T_2) - W = 0$

$T_1 + T_2 = W$

$3.8 + 4.4 = W$

W = 8.2N

4.8. Two blocks of masses 5kg and 3kg are suspended by the two strings as shown in figure. Find the tension in each string.

Figure

Ans. Given data:

m_1 = 5kg

m_2 = 3kg

To Find:

$T_1 = ?$

$T_2 = ?$

Solution:

Tension in string A is due to both mases.

$T_1 = w_1 + w_2$

$T_1 = m_1g + m_2g$

$T_1 = (m_1 + m_2)\, g$

$T_1 = (5 + 3)\, 10$

$T_1 = 8 \times 10$

$\mathbf{T_1 = 80N}$

Also

Tension is string B is due to second mass only.

$T_2 = w_2$

$T_2 = m_2g$

$T_2 = 3 \times 10$

$\mathbf{T_2 = 30N}$

4.9. A nut has been tightened by a force of 200N using 10cm long spanner. What length of a spanner is required to loosen the same nut with 150N force?

Ans. Given data:

$F_1 = 200N$

$L_1 = 10cm = 0.1m$

$F_2 = 50N$

To Find:

$L_2 = ?$

Solution:

$\tau_1 = \tau_2$

$F_1 \times L_1 = F_2 \times L_2$

$L_2 = \frac{F_1 \times L_1}{F_2}$

$= \frac{200 \times 0.1}{150}$

$L_2 = 0.133m$

$L_2 = 0.133 \times 100cm$

$\mathbf{L_2 = 13.3cm}$

4.10. A block of mass 10kg is suspended at a distance of 20cm from the centre of a uniform bar 1m logn. What force is required to balance it at its centre of gravity by applying the force at the other end of the bar?

Ans. Given data:

Mass of block m = 10kg

Weight of block = w = mg

= 10 × 10 = 100N

Length of bar = L = 1m

Distance of block from center of nod = 20cm = $\frac{20}{100}$ m = 0.20m

Distance of force from center = 50cm = $\frac{50}{100}$ m = 0.50m

To Find:

F = ?

Solution:

Now using condition of equilibrium.

$F \times L_2 = w \times L_1$

$F \times 0.5 = 100 \times 0.2$

$F = \frac{100 \times 0.2}{0.50}$

F = 40N

Chapter # 5 (Gravitation)

- **Choose the correct answer from the following choices:**

i. Earth's gravitational force of attraction vanishes at: (LHR 12-I, 14-I) (MN 14-II) (FB 13-II) (BP II- I) (RWP 15-II) (SG, SW 15-I)

(a) 6400km (b) infinity (c) 42300km (d) 1000km

ii. Value of g increases with the: (SW 13-I) (SG 15-II) (AK 15-I)

(a)increases in mass of the body (b) increase in altitude
(c)decrease in altitude (d) none of the above

iii. The value of g at a height one Earth's radius above the surfaceof the Earth is: (SW 14- I) (SG 14-II) (RWP, LHR 13-I-II) (AK 12-I) (SG 10-II) (BP, SW II-I) (RWP, BP 15-I)

(a) 2g (b) ½ g (c) $^1/_3$g (d) ¼ g

iv. The value of g on moon's surface is 1.6ms^{-2}. What will be the weight of a 100 kg body on the surface of the moon? (GW 13-I) (AK 10-I) (SW 09-I)

(a) 100N (b) 160N (c) 1000N (d) 1600N

v. The altitude of geostationary orbits in which communication satellites are launched above the surface of the Earth is: (RWP 14-II) (RWP 10-II) (AK, SG II-II)

(a) 850km (b) 1000km (c) 6400km (d) 42,300km

vi. The orbital speed of a or orbit satellite is: (FB 14-I) (GW, AK, DG 13-I-II) (FB 14-II) (SG 09-I) (LHR 09-II, 15-I) (MN 15-II)

(a)zero (b) 8ms^{-1} (c) 800ms^{-1} (d) 8000ms^{-1}

ANSWER:

i.	b.	**ii.**	c.	**iii.**	d.	**iv.**	b.	**v.**	d.
vi.	a.								

Short Questions

- **Write short answers of the following questions:**

5.1. What is meant by the force of gravitation? (SG 14-I-II) (DG, BP, DG, MN 13-II) (DG 14-II) (FB, GW 15-II) (LHR, RWP, SG 15-I)

Ans: **Force of gravitation:**"The force due to which every body of the universe attracts every other body is called force of gravitation".

Formula: $F = \frac{Gm_1m_2}{r^2}$

5.2. What is a field force? (AK 14-I) (DG, AK, SG, MN 14-II) (RWP 15-I) (AK, SG, SW 12-I)

Ans: **Field force:** The force acting on the body whether the body is in contact with it or not is called field force.

Example: Gravitational force.

5.3. Do you attract the Earth or the Earth attracts you? Which oen is attraction with a larger force? Yoru or the Earth. (RWP 09-I) (LHR II-I)

Ans: Yes, Earth attracts us and in reaction we attract Earth as well. Both of these forces are equal in magnitude.

5.4. How can you say that gravitational force is a field force? (FB, RWP 13-I) (FB 15-I)

Ans: As gravitational force is a non contact force. For example, velocity of a body, thrown up, goes on decreasing while on return its velocity goes on increasing. This is due to the gravitational pull of the earth action on the body whether the body is in contact with earth or not. So, gravitational force is a field force.

5.5. Why earlier scientists could not gues about the gravitational force? (SG 09-I)

Ans: The earlier scientists could not guess about the gravitational force because they were not known about the cocept of gravity. Concept of gravity was put forth by ISSAC NEWTON in 1665.

5.6. Explain, what is meant by gravitational field strength? (RWP, AK, LHR 14 14-II) (FB, SW, MN, AK, LHR 13-II) (RWP, 15-I) (FB, RWP 15-II)

Ans: **Gravitatioanl field strength:** In the gravitational field of the earth, the gravitational force per unit mass is called the gravitational field strength of the earth.

Value: At any place, its value is $10Nkg^{-1}$.

5.7. Explain the law of gravitation. (LHR 14-II) (BP, LHR, DG 14 I-II) (FB 15-II) (LHR 08-I) (GW 10-I) (AK 12-II)

Ans: **Law of gravitation:** The force of attraction between two objects is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

Formula: $F = \frac{Gm_1m_2}{r^2}$

Law of gravitation depends upon masses of objects and distance between them.

i. Greater the masses of objects, greater will be force of gravitation.

ii. Greater the distance between objects, less will be force of gravitation.

5.8. Why law of gravitation is important to us?(MN, FB 14-I) (FB 12-I) (GW II-I) (LHR 09-I)

Ans: It is important to us becaue it helps us to understand why.

i. Binds all terrestrial objects to earth.

ii. Keeps the atmosphere close to earth.

iii. Keeps moon revolving around the earth.

iv. Gravitational pull of sun on planet keeps them revolving around sun.

5.9. How the mass of earth can be determined? (MN 14-I) (SG 13-II) (AK 12-I) (FB 09-II) (MN 15-I)

Ans: Mass of earth can be calculated with the help of law of gravitation.

$$M_e = \frac{R^2 g}{G}$$

After calculation

$$M_e = 6 \times 10^{24} kg$$

5.10. Why does the value of g vary from place to place? (DG, MN, BP, FB 13 I-II) (SW, AK, BP, RWP 14-II) (AK, SG 14-I) (BP 15-I)

Ans:

$$g_h = \frac{GM_e}{(R+h)^2}$$

The value of g is inversely proportional to the square of the radious of the earth. But it does not remain constant and decreases with altitude, that's why the value of g varies from place to place.

5.11. Can you determine the mass of our moon? If yes, then what you need to know? (BP 09-I)

Ans: Yes, we can calculate the mass of our moon by using formula.

$$M_m = \frac{R^2 g_m}{G}$$

<u>Need to know:</u>

i. Value of radius of moon.

ii. Gravitational acceleration on moon.

iii. Gravitational constant on moon.

5.12. Explain how the value of g varies with altitude. (GW 14-I) (FB, SG, MN 15-I) (AK, SG, SW, MN 15-II)

Ans: Value of gravitational acceleration is determined by following formula:

$$g_h = \frac{GM_e}{(R+h)^2}$$

So, g is inversely proportional to $(R+h)^2$. It means that with increasing altitude, value of g decrease.

5.13. How Newton's law of gravitation helps in understanding the motion of satellites? (BP, SW, MN II-I)

Ans: A satellite requires centripetal force that keeps it to move around the earth. The gravitational force of attraction between the satellite and the earth provides the necessary centripetal force. This centripetal force is introduced by the Newton. So in this way. Newton's law of gravitation helps in understanding the motion of satellites.

5.14. What are artificial satellites? (LHR 13-I) (SW, FB 14-I) (FB 15-I) (AK 10-I) (LHR II-I) (SW 12-II)

Ans: Artificial satellites: Scientists have sent many objects into space. Some of these objects revolve around the earth. These are called artificial satellites.

<u>Example:</u> Geostationary satellites

5.15. Why communication satellites are stationed at geostationary orbits? (GW 14-I) (DG, BP 14-II) (SW, GW 13-II) (FB, GW 10-II)

Ans: Communication satellites takes 24 hours to complete their one revlotion around the earth. As earth also completes its one rotation about its axis in 24 hours, hence. These communication satellites appear stationary with respect to earth. It si due to this reason that the orbit of such a satellites is called geostationary orbit".

5.16. On what factors the orbital speed of a satellite depends? (RWP 15-II) (AK 15-I) (SW 12-I)

Ans: Orbital speed of the satellite depends only on height of satellites from surfaceof earth because both gravitational acceleration of earth and radius of the earth are cosntnats. It is clear from the given formula:

$$v_o = \sqrt{g_h(R + h)}$$

Important Formulas

- $g = \frac{GM_e}{R^2}$ OR $M_e = \frac{gR^2}{G}$
- $g_h = \frac{GM_e}{(R+h)^2}$
- $F = G\frac{m_1 m_2}{r^2}$
- $v_o = \sqrt{g_h(R + h)}$

Important Values

- Gravitatioanl constant = G = $6.67 \times 10^{-11} Nm^2kg^{-2}$
- Mass of earth = M_e = $6 \times 10^{24}kg$
- Radius of earth = R = $6.4 \times 10^6 m$
- Orbital speed = v_o = $29000kmh^{-1}(8kms^{-1})$

Numericals

5.1. Find the gravitational force of attraction between two spheres each of mass 1000kg. The distance between the centers of the spheres is 0.5m. (FB 12-I)

Ans. Given data:

m_1 = 1000kg
m_2 = 1000kg
r = 0.5m
G = $6.67 \times 10^{-11} Nm^2kg^{-2}$

To Find:

F = ?

Solution:

$$F = G\frac{m_1 m_2}{r^2}$$

$$= \frac{6.67 \times 10^{-11} \times 1000 \times 1000}{(0.5)^2}$$

$$\mathbf{F = 2.67 \times 10^{-4} N}$$

5.2. The gravitational force between two identical lead spheres kept at 1m apart is 0.006673N. EFind their masses. (SW 13-II) (MN 10-I)

Ans. Given data:

F = 0.006673N
r = 1m
G = $6.67 \times 10^{-11} Nm^2Kg^{-2}$

To Find:

m_1 = ?
m_2 = ?

Solution:

As the masses are identical so,

$m = m_1 = m_2$

$F = G\frac{m_1.m_2}{d^2}$

Since $m_1 = m_2 = m$

$F = G.\frac{m^2}{d^2}$

Or $m^2 = \frac{F.d^2}{G}$

Using the values, we have

$m_2 = \frac{0.006673\times(1)^2}{6.673\times10^{-11}}$

$m_2 = \frac{0.006673\times10^{-11}}{6.673}$

$m_2 = 0.001 \times 10^{11}$

$m_2 = 100000000$

Taking square root on both sides

$m = 10000kg$

So,

$m_1 = 10000kg$

$m_2 = 10000kg$

5.3. Find the acceleration due to gravity on the surface of the Mars. The mass of Mars is 6.42×10^{23}kg and its radius is 3370km. (MN, SW, SG 12-II)

Ans. Given data:

$G = 6.67\times10^{-11}Nm^2kg^{-2}$

$M = 6.42\times10^{23}kg$

$R = 3370km = 3370 \times 1000 = 3370000m$

To Find:

$g = ?$

Solution:

$g = G.\frac{M}{R^2}$

Using the values, we have.

$g = \frac{42.82\times10^{23-11}}{113569\times10^8}$

$g = \frac{42.82\times10^{12-8}}{113569}$

$g = 0.000377\times10^4$

$g = 3.77ms^{-2}$

5.4. The acceleration due to gravity on the surface of the moon is $1.62ms^{-2}$. The radius of the moon is 1740km find the mass of the moon. (FB 09-I)

Ans. Given data:

$g_m = 1.62ms^{-2}$

$R = 1740km$

= 1740000m

To Find:

M_m = (Mass of moon) = ?

Solution:

$g_m = \frac{GM_m}{R^2}$

$M_m = \frac{gR^2}{G}$

$M_m = \frac{(1.62)\times(1740000)^2}{6.67\times10^{-11}}$

$M_m = \frac{1.62\times(1.74\times10^6)^2}{6.67\times10^{-11}}$

$M_m = \frac{1.62\times(3.0276\times10^{12})\times10^{11}}{6.67}$

$M_m = 0.735 \times 11^{12}\times 10^{11}$

$\mathbf{M_m = 7.35 \times 10^{22}kg}$

5.5. Calculate value of g at a height of 3600km above the surface of the earth. (MN 09-II) (GW II-II)

Ans. Given data:

h = 3600km

= 3600×1000

= 3600000m

To Find:

g_h = ?

Solution:

$g_h = \frac{GM}{(R+h)^2}$

$= \frac{6.67\times10^{-11}\times6\times10^{24}}{(3600000+6.4\times10^6)^2}$

$= \frac{40.02\times10^{13}}{(3.6\times10^6+6.4\times10^6)^2}$

$= \frac{40.02\times10^{13}}{(10\times10^6)^2}$

$= \frac{40.02\times10^{13}}{(10^7)^2}$

$= \frac{40.02\times10^{13}}{10^{14}}$

$= \frac{40.02}{10^{14-13}}$

$= \frac{40.02}{10}$

$\mathbf{g_h = 4.0ms^{-2}}$

5.6. Find the value of g due to earth at geostationary satellite. The radius of the geostationary orbit is 48700km. (AK 15-I)

Ans. Given data:

$R = 48700km = 48700 \times 1000m$

$R = 48700000m$

To Find:

$g = ?$

Solution:

$$g = \frac{GM_e}{R^2}$$

$$g = \frac{(6.673\times10^{-11})(6.0\times10^{24})}{(48700000)^2}$$

$$g = \frac{40.03\times10^{13}}{(4.87\times10^7)^2}$$

$$g = \frac{40.03\times10^{13}}{23.72\times10^{14}}$$

$g = 1.68\times10^{13-14}$

$g = 1.68\times10^{-1}$

$\mathbf{g = 0.168ms^{-2}}$

$\mathbf{g = 0.17ms^{-2}}$

5.7. The value of g is $4ms^{-2}$ at a distance of 10000km from the centre of the earth. Find the mass of the earth. (FB 12-I) (LHR 09-I)

Ans. Given data:

$g = 4ms^{-2}$

$R = 1000km$

$= 1000 \times 1000m$

$= 1 \times 10^7m$

To Find:

$M_e = ?$

Solution:

$$g_h = \frac{GM_e}{(R+h)^2}$$

or $$M_e = \frac{g_h(R+h)^2}{G}$$

Using the values.

$$M_e = \frac{(4)(1\times10^7)^2}{6.673\times10^{-11}} kg$$

$$M_e = \frac{4}{6.673}\times 10^{14+11}kg$$

$= 0.599 \times 10^{14+11}$

$= 0.599 \times 10^{25}$

$\mathbf{M_e = 5.99 \times 10^{24}kg}$

5.8. At what altitude the value of g would become one fourth than on the surface of the earth? (LHR 08-I)

Ans. Given data:

$M_e = 6.0 \times 10^{24}$kg

$R_e = 6.4 \times 10^6$m

$g_h = \frac{1}{4} g = \frac{1}{4} \times 10 = 2.5ms^{-2}$

To Find:

$h = ?$

Solution:

We know that

$$g_h = \frac{GM_e}{(R+h)^2}$$

$$(R+h)^2 = \frac{GM_e}{g_h}$$

$$(6.4 \times 10^6 + h)^2 = \frac{6.67\times10^{-11}\times6\times10^{-24}}{2.5}$$

$$(6.4 \times 10^6 + h)^2 = \frac{40.02\times10^{11+24}}{2.5}$$

By taking square root on both sides.

$6.4 \times 10^6 + h = 12.65 \times 10^6$

$h = 12.65 \times 10^6 - 6.4 \times 10^6$

$h = 10^6 (12.65 - 6.4)$

$\mathbf{h = 6.25 \times 10^6 m}$

5.9. A polar satellite is launched at 850km above earth. Find its orbital speed.

Ans. Given data:

$R = 6.4 \times 10^6$m

$h = 850$km

$= 850 \times 1000$m

$= 850000$m

$= 0.85 \times 10^6$m

To Find:

$V_o = ?$

Solution:

We know that

$$V_o = \sqrt{g_h(R+h)}$$

$$= \frac{GM_e}{(R+h)^2}$$

Putting the equation. Value of g_h.

$$V_o = \sqrt{\left(\frac{GM_e}{(R+h)^2}\right)(R+h)}$$

$$V_o = \sqrt{\frac{GM_e}{(R+h)}}$$

$$V_o = \sqrt{\frac{6.67\times10^{-11}\times6\times10^{24}}{(6.4\times10^6+0.85\times10^6)}}$$

$$V_o = \sqrt{\frac{40.02\times10^{-11+24}}{(10^6\times7.25)}}$$

$V_o = \sqrt{\frac{40.02 \times 10^{13}}{7.25 \times 10^6}}$

$V_o = \sqrt{5.52 \times 10^{13-6}}$

$V_o = \sqrt{5.52 \times 10^7}$

$V_o = \sqrt{55.2 \times 10^6}$

$V_o = 7.4296 \times 10^3$

$\mathbf{V_o = 7429.6ms^{-1}}$

- **If vaue of G is taken 6.673 × 10^{-11}, answer would be 7431ms^{-1}.**

5.10. A communication, satellite is launched at 42000km above the earth. Find its orbital speed. (SW 10-I)

Ans. Given data:

$h = 42000km$

$= 42000 \times 1000m$

$= 4200000m$

To Find:

$V_o = ?$

Solution:

$g_h = \frac{GM_e}{(R+h)^2}$

Using the values.

$g_h = \frac{(6.673 \times 10^{-11}) \times (6 \times 10^{24})}{(6.4 \times 10^6 + 42 \times 10^6)^2}$

$g_h = \frac{40.038 \times 10^{13}}{(6.4+42)^2 \times (10^6)^2} ms^{-2}$

$= \frac{40.02 \times 10^{23}}{234256 \times 10^{10}}$

$= 0.00017 \times 10^{13-10}$

$= 0.00017 \times 10^3$

$g_h = 0.17ms^{-2}$

Now

$v_o = \sqrt{g_h(R+h)}$

$v_o = \sqrt{0.17(6.4 \times 10^6 + 42000000)}$

$v_o = \sqrt{0.17(48400000)}$

$v_o = \sqrt{826852.04}$

$v_o = 2875.51ms^{-1}$

$\mathbf{v_o = 2876ms^{-1}}$

Chapter # 6 (Work and energy)

- **Choose the correct answer from the following choices:**

i. **The work done will be zero when the angle between the force and the distance is:** (RWP 15-II) (AK 15-I) (SW 12-I)
(a) 45° (b) 60° (c) 90° (d) 180°

ii. **If the direction of motion of the force is perpendicular to the direction of motion of body, then work done will be.** (LHR 09-I) (SG, GW 10-I) (AK 12-I)
(a)maximum (b) minimum (c) zero (d) none

iii. **If the velocity of a body becomes double, then its kinetic energy will:**
(a)remain the same (b) become double (c) become four times (d) become half

iv. **The work done in lifting a brick of mass 2 kg through a height of 5 m above ground will be:** (LHR 14-I) (AK 13-II) (GW II-II) (SG 10-II) (AK 10-I) (FB 09-II)
(a) 2.5J (b) 10J (c) 50J (d) 100J

v. **The kinetic energy of a body of mass 2 kg is 25 J. It is speed is?**
(a) $5ms^{-1}$ (b) $12.5ms^{-1}$ (c) $25ms^{-1}$ (d) $50ms^{-1}$

vi. **Which one of the following converts light energy into electrical energy?** (LHR 14-I) (MN 14-II) (LHR 08-II) (SW 09-II, 10-I, 13-I) (MN 10-II)
(a)electric bulb (b) electric generator (c) photocell (d) electric cell

vii. **When a body is lifted through a height h, the work done on it appears in the form of its:** (LHR 10-I)
(a)kinetic energy (b) potential energy (c)elasetic potential energy (d) geothermal energy

viii. **The energy stored in coal is.** (RWP 14-I, 15-I) (SG 14-II) (LHR 08-I) (GW 09-II) (SG, FB, BP 15-II)
(a)heat energy (b) kinetic energy (c) chemical energy (d) nuclear energy

ix. **The energy stored in a dam is:** (DG, GW 14-I) (SG 14-II) (GW 13-I) (FB, GW 08-I) (DG, LHR 09-II) (FB 15-I)
(a)electric energy (b) potential energy (c) kinetic energy (d) thermal energy

x. **In Einstein's mass-energy equation, c is the:** (LHR II-II) (FB 12-I) (MN 15-I) (MN 15-II)
(a)speed of sound (b) speed of light (c) speed of electron (d) speed of earth

xi. **Rate of doing work is called:** (GW 10-I, 13-II) (RWP, FB 14-I) (RWP 09-I) (SW 15-II)
(a)energy (b) torque (c) power (d) momentum

ANSWER:

i.	c.	ii.	c.	iii.	c.	iv.	d.	v.	a.
vi.	c.	vii.	b.	viii.	c.	ix.	b.	x.	b.
xi.	c.								

Short Questions

- **Write short answers of the following questions:**

6.1. **Define work. What is its SI unit?** (LHR,SW 14-I) (LHR 13-II) (FB 13-I) (SG, DG, MN 14-II) (FB 15-II) (LHR, RWP 15-I) (BPM, SW, AK 12-I) (SG, LHR 08-I) (GW 08-II) (LHR 09-I)

Ans: **Work:** Work is said to be done when force acting on a body displaces it in the direction of the force.

Formula: Work = Force × distance

$$W = FS$$

SI unit of work: SI unit of work is joule (J) or Nm.

6.2. **Why do we need energy?** (FB 08-I) (LHR II-I) (GW 09-I)

Ans: **i.**Eenergy is used by us to perform many activities of life.

ii. Energy is necessary for running and walking for humans.

6.3. When does a force do work? Expalin. (RWP, MN, GW 13-I) (RWP 08-I) (FB, LHR 12-I)

Ans: Work is done when force acting on a bdoydisplaces it in the direction of applied force.

6.4. Define energy, give two types of mechanical energy. (BP, MN 14-I) (MN, RWP 14-II) (GW 13-II) (GW, AK 14 I-II) (SW, BP, DG, FB, LHR 13-I-II) (BP, RWP 15-I) (FB 15-II)

Ans: **Energy:** A body possess energy if it is capable to do work.

Types of mechanical energy:

Mechanical energy has two following types:

i. Kinetic energy **ii.** Potential energy

Kinetic energy:(LHR, SW 14-I) (SW, SG 14-II)

The energy possessed by a body due to its motion is called its kinetic energy.

Formula: K.E = ½ mv^2

Potential energy:(SW, BP 14-I) (RWP, SG 14-II) (BP II-I, 12-I)

The ability of a body to do work due to its position is knownas its potential energy.

Formula:i.e. P.E = mgh

6.5. Define potential energy and derive its relation. (MN 13-II) (GW 09-I) (GW, SW, AK 12-I) (LHR 08-I)

Ans: **Potential energy:** Energy possessed by a body due to its position is called potential energy. P.E = mgh.

Derivation:

$$P.E = work$$

$$P.E = F.d = (mg)\,(h)$$

$$\mathbf{P.E = mgh}$$

6.6. Define K.E and derive its relation. (BP 13-II) (LHR 08-I) (GW 08-II) (LHR 09-I) (RWP, FB 15-II) (LHR 15-I)

Ans: **Kinetic energy:** Energy possessed by a body due to its motion is called kinetic energy.

Derivation: If a ball moves with initial velocity vi after covering some distance, it stops and its vf is zero. During this, it does work against force of friction (F = ma) so

Please write from page # 122, see the text book.

6.7. Why fossils fuels are called non-renewable form of energy? (SW, RWP, BP 13-I) (DG, MN 14-II) (SW, SG 15-I) (MN 15-II)

Ans: The fossil fuels take millions of years for their formation. So, these are known as non-renewable resources.

6.8. How is energy converted from one form to another? Explain. (FB 08-I) (LHR II-I) (GW 09-I)

Ans: With the help of different devices and through chemical reactions energy is converted from one form to another.

Example: Solar cells are used to convert light energy into electrical energy.

6.9. Which form of energy is most preferred and why? (FB, SW, SG, GW 09-II)

Ans: Solar energy is most preferred energy because sunglight does not pollute the environment in any way.

Solar energy reaching Earth is thousand times more than the energy consumption of mankind.

6.10. Name a device that converts mechanical energy into electrical energy. (FB 08-I) (RP0 8 II-II)

Ans: Generator is a device that converts mechanical energy into electrical energy.

6.11. Name the five devices that convert electrical energy into mechanical energy, (MN 14-I, 15-II) (LHR 12-II)

Ans: **Devices:**

i. Washing machine
ii. Electric motor
iii. Electric grinder
iv. Electric spinner
v. Juicer

6.12. What is meant by the efficiency of a system? (AK 14-I) (RWP, SW 13-I) (LHR, DG, FB, MN, BP, SW 14 I-II) (GW, FB 09-I) (RWP 15-II) (SG 15-I)

Ans: **Efficiency:** Efficiency of a system is the ratio of required form of energy obtained from a system as output to the total energy given to it as input.

Formula:

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}}$$

Input is the energy given to machine to work while output is work done by machine.

6.13. What is meant by the term power? (SW 15-II) (FB 15-I) (FB 14-II) (SW, AK, GW, RWP, SG, LHR 14-I-II) (FB, SW 13 I-II) (MN 13-II)

Ans: **Power:** Power is defined as the rate of doing work.

Formula:

$$\text{Power} = \frac{\text{Work}}{\text{Time}}$$

$$\text{i.e. } P = \frac{W}{t}$$

Unit: The SI unit of power is watt (W).

6.14. How can you find the efficiency of a system? (LHR, MN 14-I) (BP, FB 14-II) (BP 15-I) (LHR 12-I)

Ans: Efficiency of a system can be determined by following formula.

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}}$$

$$\%\ \text{Efficiency} = \frac{\text{Output}}{\text{Input}} \times 100$$

6.15. Define watt. (GW, BP 14-I) (AK 14-II) (DG 13-II) (FB 15-I) (LHR, GW, DG 08-I) (LHR II-I) (GW II-II)

Ans: **Watt:** The power of a body is one watt if it does work at the rate of 1 joule per second ($1Js^{-1}$).

$$1\text{watt} = \frac{1\text{J}}{1\text{sec}}$$

Important Formulas

- $\%\text{Efficiency} = \frac{\text{output}}{\text{input}} \times 100$
- $\text{Efficiency} = \frac{\text{output}}{\text{input}}$
- W = FS
- P = F.V or P = W/t
- K.E = ½ mv^2
- P.E = mgh
- E = mc^2

Important Values

- Speed of light = e = 3 × $108ms^{-1}$
- Density of water = $1000kgm^{-3}$
- Mass of 1 liter water = 1kg
- 1hp = 746 watt
- 1MJ = 10^6J

Units:

- Work = Joule
- Power = Watt
- Energy = Joule
  (1 joule = Newton meter)
  (Watt = Joule/sec)

Numericals

6.1. A man has pulled a cart through 35m applying a force of 300N. Find the work doen by the man. (LHR 08-I) (RWP 15-I) (RWP 15-II)

Ans. Given data:

S = 35m

F = 300N

To Find:

Work = W = ?

Solution:

W = FS

= 300×35

W = 10500J

6.2. A block weighing 20N is lifted 6m vertically upward. Calculate potential energy stored in it. (SG, SW 13-II) (FB 14-II) (RWP 15-II) (SW 12-I)

Ans. Given Data:

Weight = w = 20N

h = 6m

To Find:

P.E = ?

Solution:

P.E = Work done

= F.d = mgh = w.h

= 20×6

P.E = 120 J

6.3. A car weighing 12kN has speed of 20ms^{-1}. Find its kinetic energy. (GW 14-II) (GW 13-I) (SG 09-I) (SG 12-I) (BP, LHR 15-I)

Ans. Given data:

W = 12kN

= 12×10^3 = 12000N

V = 20ms^{-1}

To Find:

K.E = ?

Solution:

K.E = $\frac{1}{2}mv^2$………. (1)

Now

w = mg

$m = \frac{W}{g} = \frac{12000}{10} = 1200kg$

Put this value in eq. (1)

$K.E = \frac{1}{2} \times 1200 \times (20)^2$

$= \frac{1}{2} \times 1200 \times 400$

$= 240000J$

K.E = 240kJ

6.4. A 500g stone is thrown up with a velocity of 15ms^{-1}. Find its. (GW 14-I) (GW 09-II)

(a) P.E at its maximum height. (FB, LHR 13-I) (GW 14-I)

(b) K.E when it hits the ground.

Ans. Given data:

$m = 500g$

$= \frac{500}{1000}$

$= 0.5kg$

$v = 15ms^{-1}$

To Find:

P.E = ?

K.E = ?

Solutions:

$K.E = \frac{1}{2} mv^2$

$= \frac{1}{2} \times 0.5 \times (15)^2$

$K.E = 56.25J$

K.E = P.E

So

P.E will also be = 56.25J

Because energy is converted one form to another but it remains same.

6.5. On reaching the top of a slope 6m high from its bottom, a cyclist has a speed of 1.5ms^{-1}. Find the K.E and P.E of the cyclist. The mass of the cyclist and his bicycle is 40kg. (SW1 5-I)

Ans. Givne data:

$h = 6cm$

$g = 1.5ms^{-1}$

$m = 40kg$

To Find:

K.E = ?

P.E = ?

Solutions:

$K.E = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 40 \times (1.5)^2$

$= 20 \times (1.5)^2$

K.E = 45j

$P.E = mgh$
$= 40 \times 10 \times 6$
$P.E = 2400J$

6.6. A motor boat moves at a steady speed of $4ms^{-1}$, water resistance acting on it is 4000N. Calculate the power of its engine? (BP, FB, LHR 13-II) (FB, BP, LHR, SG 10-II)

Ans. Given data:

$v = 4ms^{-1}$
$F = 4000N$

To Find:

$P = ?$

Solutions:

$P = F.v$
$P = 4000 \times 4$
$P = 16000watt$
$P = 16 \times 1000$
$P = 16 \times 10^3$
$P = 16kW$

6.7. A man pulls a bloc kwith a force of 300N through 50m in 60s. Find the power used by him to pull the block. (FB 15-II)

Ans. Given data:

$F = 300N$
$S = 50m$
$t = 60s$

To Find:

$P = ?$

Solutions:

$P = \frac{W}{t}$
$\therefore W = F \times S$
$P = \frac{F \times S}{t}$
$= \frac{300 \times 50}{600}$
$P = 250watt$

6.8. A 50kg man moved 25 steps up in 20 seconds. Find his power, if each step is 16cm high. (MN 10-I) (GW II-I)

Ans. Given data:

$m = 50kg$
$t = 20s$

Height of each step $= 16cm = \frac{16}{100}$
$= 0.16m$
Height of 25 steps $= 0.16 \times 25$
$= 4m$

To Find:

P = ?

Solutions:

$P = \frac{W}{t} = \frac{mgh}{t}$

$P = \frac{50 \times 10 \times 4}{20}$

P = 100watt

6.9. Calculate the power of a pump which can lift 200kg of water through a height of 6m in 10 seconds. (SG 12-I) (AK 14-I) (BP 13-I)

Ans. Given data:

m = 200kg

h = 6m

t = 10s

To Find:

P = ?

Solutions:

$P = \frac{W}{t} = \frac{mgh}{t}$

$P = \frac{50 \times 10 \times 4}{20}$

P = 1200watt

6.10. An electric motor of 1hp is used to run water pump. The water pump takes 10 minutes to fill an overhead tank. The tank has a capacity of 800 liters and height of 15m. Find the actual work done of motor to fill the tank. Also find efficiency of the system. (FB 15-I) (MN 09-I) (LHR 09-II)

(Density of water = 1000kgm^{-1})

Mass of 1 litre of water = 1kg)

Ans. Given data:

V = 800 liters

t = 100min

= 10×60

P = 1hP

∴ (1hP = 746 watt)

P = 746 watt

h = 15m

To Find:

W = ?

Efficiency = ?

Solutions:

$P = \frac{W}{t}$

$W = P \times t$

$= 746 \times 600$

Input = W = 447600J

We know that

1 ltr of water = 1kg of water

So,

800litres = 800kg

m = 800kg

Now

W = mgh

= $800 \times 10 \times 15$

W = 120000J

Here

Work input = 447600J

Ouptut = 120000J

% Efficiency = $\frac{\text{output}}{\text{input}} \times 100$

= $\frac{120000}{447600} \times 100$

% Efficiency = 26.8%

Chapter # 7 (Properties of matter)

- **Choose the correct answer from the following choices:**

i. In which of the following state molecules do not leave their position? (LHR, MN 14-I) (BP, FB 14-II) (BP 15-I) (LHR 12-I)

(a)solid (b) liquid (c) gas (d) plasma

ii. Which of the substance is the highest one? (SG 13-II) (GW 13-I) (LHR 08-I) (GW 10-I) (AK, GW 10-II) (S, RWP 12-I)

(a)copper (b) mercury (c)aluminium (d) lead

iii. SI unit of pressure is Pascal, which is equal to: (BP, LHR, FB 14-I) (SG, MN 14-II) (SW, LHR 13-II) (LHR 08-II) (GW 10-I) (FB 09-I) (MN, FB 15-I) (BP, SG 15-II)

(a) 10^4Nm^{-2} (b) $1Nm^{-2}$ (c) 10^2Nm^{-2} (d) 10^3Nm^{-2}

iv. What should be the approximate length of a glass tube to construct a water barometer? (SG 12-II) (LHR, FB 14-II) (AK, DG, BP, MN 13 I-II) (MN 08-II, 12-I, 15-II)

(a) 0.5m (b) 1m (c) 2.5m (d) 11m

v. According to Archimedes, upthrust is equal to:(FB 08-I) (GW 12-I) (BP 12-II)

(a)weight of displaced liqu id (b) volume of displaced liquid

(c)massofdisplaced liquid (d) none of these

vi. The density of a substance can be found with the help of: (BP, AK, SW 09-I)

(a) Pascal's law (b) Hooke's law

(c) Archimedes principle (d) Principle of floatation

vii. According to Hooke's law: (MN 14-I) (FB, SG 15-II) (AK 15-I) (MN 08-I) (FB 10-II) (GW II-II)

(a)stress $\times$ strain = constant (b) stress / strain = constant

(c)strain / stress = constant (d) stress = strain

The following force-extension graphs of a spring are drawn on the same scale. Answer the questions given below from (viii) to (x).

(a) (b)

(c) (d)

viii. Which graph does not obey Hooke's law?

(a)	(b)	(c)	(d)

ix. **Which graps gives the smallest value of spring constant?**

(a)	(b)	(c)	(d)

x. **Which graph gives the largest value of spring constant?**

(a)	(b)	(c)	(d)

ANSWER:

i.	a.	ii.	c.	iii.	b.	iv.	d.	v.	a.
vi.	c.	vii.	b.	viii.	c.	ix.	d.	x.	a.

Short Questions

- **Write short answers of the following questions:**

7.1. How kinetic molecular model of matter is helpful in differentiating various states of matter? (MN, DG, LHR 13-I) (MN, RWPM, SG, BP, DG 14 I-II) (FB, SW, SG 13-II) (SW, MN 15-I) (FB, SG, SW 15-II) (SW 08-II) (AK 08-I)

Ans: Kinetic molecular model is used to explain three states of matter solid, liquid and gas.

Solid:(MN, RWP 14-II) (LHR 14-I)

In solids molecules are very close to one another, they posses greater attractive forces.

Liquids: Distance between molecules is greater as compared to solids.

Gases: In gases distance between molecules is too much.

7.2. What is meant by density? What is its SI unit? (SW, FB 14-II) (DG, RWP, LHR, AK, BP 13 I-II) (DG 14-I) (RWP 15-I) (RWP 15-II) (AK, GW, BP, SG 10-II) (AK, GW, BP, SG II-II)

Ans: **Density:** Density of a substance is defined as the mass per unit volume.

Formula: Density = $\frac{\text{Mass}}{\text{Volume}}$

$$d = \frac{m}{v}$$

Unit: The SI unit of density is kilogram per cubic metre (kgm^{-3}).

7.3. Does there exist a fourth state of matter? What is that? (GW 14-I) (FB 13-II) (GW 13 I-II) (BP 14-I) (MN 09-I) (MN II-I) (LHR 08-I) (GW 08-II) (RWP, BP 15-I)

Ans: Yes, there exists a fourth state of matter that is called **plasma.**

At very high temperature, the matter assumes the state of ions and electrons this is called plasma.

7.4. Can we use a hydrometer to measure the density of milk? (AK 14-I) (SW, SG II-II) (GW 08-II) (AK 15-II)

Ans: Hydrometer is a device which is used to measure the density of fluid.as the hydrometer is a glass tube with a scale marked on its stem and heavy weight in the bottom. It is partially immersed in the milk that is also a fluid, the density of which is to be measured, hence we can use hydrometer to measure the density of milk.

7.5. Show that atmosphere exerts pressure. (BP 13-I) (MN, SG II-I) (BP 09-I) (BP 15-I)

Ans: **Experiment:** Boil an empty tin, half-filled with water, cap the tin. Let it cool under tap water. The tin will get crumpled as the water cool down. As the steam condense, the pressure inside the metal tin decreases, the external atmospheric pressure that is higher, crushes the tin.

7.6. Define the term pressure. (SW, RWP, FB, AK 14-I) (SG, DG, AK 14-II) (MN 13-I) (AK 13-II) (GW, LHR 08-II) (MN, LHR, FB 15-I) (FB 15-II)

Ans: **Pressure:** The force acting normally on unti area at the surface of a body is called pressure.

Formula: Pressure = $\frac{\text{Force}}{\text{Area}}$

$$P = \frac{F}{A}$$

Units: In SI, the unit of pressure is Newton per square metre (Nm^{-2}) or Pascal (Pa).

Physical quantity: It is a scalar quantity.

7.7. It is easy to remove air from a ballon but it is very difficult to remove air from a glass bottle. Why? (BP 09-I) (SG II-I)

Ans: It is very difficult to remove air from a glass bottle because air pressure in the bottle is less than atmospheric pressure but it is easy to remove air from a ballon due to lower external pressure.

7.8. Why water is not suitable to be used in a barometer? (LHR 14-15-II) (SG 09-II)

Ans: Mercury is 13.6 time denser than water. Atmospheric pressure can hold vertical column of water about 13.6 times the height of mercury column ata place. Thus, at a sea level, vertical height of water column would be $0.76 \times 13.6 = 10.4$m. Thus, a glass tube more than 10m long is required to make a water barometer.

7.9. What is barometer? (DG 14-II) (SW 12-14-I) (AK 12-II)

Ans: **Barometer:** The instrument that measures atmospheric pressure is called barometer. One of the simple barometer is mercury barometer.

7.10. What makes a sucker pressed on a smooth wall sticks to it? (SG, SW 09-II)

Ans: Air pressure makes sucker pressed on a smooth wall stick to it.

7.11. What does it mean when the atmospheric pressure at a place fall suddenly? (SG 08-II)

Ans: A sudden fall ion atmospheric pressure often followed by a storm, rain and typhoon to occur in few hours time that cause internal energy of air decreases and coldness is produced.

7.12. Why does the atmospheric pressure vary with height? (AK 14-II) (FB 13-I) (MN 15-I) (FB 08-II)

Ans: Density of air is not uniform in the atmosphere. It decreasdes continuously as we go up. Hence atmospheric pressure is also decreased.

7.13. What changes are expected in weather if the barometer reading shows a sudden increase? (SG 14-I) (BP 09-I) (BP 12-I) (SW 09-II)

Ans: If the barometer reading shows a sudden increase or a rapid increase in atmospheric pressure, means that it will soon be followed by a decrease in the atmospheric pressure indicating poor weather ahead.

7.14. Explain the working of hydrautice press. (MN 13-I) (GW 08-I) (RWP 15-II) (FB 15-I)

Ans: Hydraulic press works on the principle of Pascal's law and conssits of two cylinders fitted with pistions of different cross sectional area.

7.15. State Pascal's law. (BP 14) (SG, SW 13-I) (GW, LHR 08-I) (FB, LHR 15-I) (RWP, SG, AK 15-II)

Ans: **Pascal's law:** Pressure applied at any point of a liquid enclosed in a container is transmitted without loss to all other parts of liquid.

7.16. What is meant by elasticity? (RWP, MN, SG 14-I) (SW 13-II) (BP 14-II) (RWP, MN 09-II) (SW 12-I)

Ans: **Elasticity:** Elasticity is the property of matter by virtue of which matter resists any force which tries to change its length, shape or volume.

7.17. What is upthrust? Explain the principle of floatation. (FB, RWP 14-II) (FB 13-I) (SW II-II) (FB 09-I) (RWP 12-II)

Ans: **Upthrust:** The fluids (liquids) exert force in the upward direction when some object is immersed into them. This is called upward thrust.

Principle of floatation: The weight of fluid displaced is equal to weight of floating object inside liquid. Then object will into sink and keep floating. It is called principle of floatation.

7.18. State Archimedes principle: (SW, FB 14-II) (RWP 08-II) (MN 10-I) (SG II-I) (DG, RWP 13-II)

Ans: **Archimedes principle:** When an object is whole or partially immersed in a liquid, an upthrust force acts on it equal to the weight of the liquid displaced. This is known as Archimedes principle.

7.19. Explain how a submarine moves up the water surface and down into water. (BP 09-II, 14) (AK 12-II, 13-II) (MN, BP 14-II) (MN 09-I) (GW II-II) (SW II-I)

Ans: If the submarine is not filled with sea water then, its weight is less than upward thrust. So that is floats on surface of sea water. But when, it is filled with water. Then its weight becomes larger as compared with upward thrust of water then it sinks into water.

7.20. What is Hooke's law? What is meant by elastic limit? (AK, GW 14-I) (LHR 13-I) (FB 15-I) (FB 08-II) (LHR 12-II)

Ans: **Hooke's law:** The strain produced in a body by the stress applied to it is directly proportional to the stress withint the elastic limit of the body is called Hooke's law.

$$\text{Stress} \propto \text{strain}$$

Elastic limit:(BP 13-II) (GW 14-II) (LHR 09-II) (AK, GW 08-I)

Elastic limit can be defined as a limit within which a body recovers its original length, volume or shape after the deforming force is removed.

7.21. Why does a piece of stone sink in water but a ship with a huge weight floats? (LHR 14-II) (RWP 13-I) (LHR 08-I) (RWP 12-II)

Ans: Ships and boats float on water. It is because the weight of an equal volume of water is greater than the weight ofships and boats. Ships have less density and large volume.

A stone sinks in water. It is because the weight of an equal volume of watrer is smaller than the weight of stone. Stone has high density and small volume.

7.22. Take a rubber band. Construct a balance of your own using a rubber band. Check its accuracy by weighing various objects. (FB 08-I)

Ans: Take a rubber band, hang it with a hook. Then pointer is attached at the lower end of it with a scale in front of pointer. Different known weights are suspended. One by one, at lower end of this rubber band. The pointer position on the scale is marked for each different known weight suspended. It is called calibration of scale for weight measurement. This makes a balance for weight measurement.

Important Formulas

- $A = \pi r^2$
- Volume = $l \times w \times h$
- Area = length $\times$ width
- Young's Modulus:
  $Y = \frac{FL_o}{A\Delta L}$
- $\rho = \frac{m}{V}$
- $\rho_{obj} = \frac{w_1}{w_1 - w_2} \times \rho_{water}$
- Pascal's law:
  $P_1 = P_2$

- $\frac{\text{Volume of ice}}{\text{Volume of water}} = \frac{\text{Denisty of water}}{\text{Density of ice}}$

$\frac{F_1}{A} = \frac{F_2}{a}$

$P = \frac{F}{A} = \frac{mg}{A}$

Important Values

- Density of ice = 920kgm^{-3}
- Density of water = 1000kgm^{-3}
- Density of A1 = 2727kgm^{-3}
- 1m = 100cm
- $1m^4 = 10^4cm^2$
- $1m^3 = 10^6cm^2$
- $1m = 10^3mm \Rightarrow 1m^2 – 10^6mm^2$

Units:

- Area = m^2
- Density = kgm^{-3}
- Young's Modulus = Y = Nm^{-2}
- Volume = m^3
- Pressure = Pa = Nm^{-2}
- Stress = Nm^{-2}

Numericals

7.1. A wooden block measuring 40cm × 10cm × 5cm has a mass 850g. Find the density of wood? (GW 08-I) (RWP 15-II) (LHR 15-I)

Ans. Given data:

Volume = V = 40cm × 10cm × 5cm

V = 2000cm^3

(1m = 100cm)

($1m^3 = (100)^3cm^3$)

$V = \frac{200}{(100)^3}m^3 = \frac{2000}{1000000}m^3 = 2\times 10^{-3}m^3$

Mass m = 850g = $\frac{850}{1000}$ k = 0.85kg

To Find:

Density of wood = ρ = ?

Solution:

Density = $\frac{\text{mass}}{\text{volume}} = \frac{m}{V} = \frac{0.85}{2\times10^{-3}} = 425kgm^{-3}$

Density of wood is 425kgm^{-3}

7.2. How much would be the volume of ice formed by freezing 1 liter of water? (LHR 09-I)

Ans. Given data:

Density of ice = 920kgm^{-3}

Volume of water = ρ_2 = 1000kgm^{-3}

Volume of water = V_2 = 1 litre

To Find:

Volume of ice = V_1 = ?

Solutions:

$$\frac{\text{Volume of ice}}{\text{Volume of water}} = \frac{\text{Density of water}}{\text{Density of ice}}$$

or $$\frac{V_1}{V_2} = \frac{\rho_2}{\rho_1}$$

or $$V_1 = \frac{\rho_2}{\rho_1} \times V_2$$

Putting the values, we have

$$V_{ice} = \frac{1000}{920} \times 1$$

Volume of ice = 1.09 liter

Thus, the volume of ice is 1.09 litre.

7.3. Calculate the volume of following objects:

(a) An iron sphere of mass 5kg, the density of iron is 8200kgm^{-3}.

(b) 200g of lead shot having density 11300kgm^{-3}. (AK, SW 13-I) (LHR 14-I) (SG 13-II) (GW 10-I)

(c) A gold bar of mass 0.2kg and ρ = 19300 kgm^{-3}.

Ans. Given data:

Mass of iron = m = 5kg

Density of iron = ρ = 8200kgm^{-3}

To Find:

Volume of iron = V = ?

Soltuion:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{m}{V}$$

$$8200 = \frac{5}{V}$$

$$\rho = \frac{5}{8200}$$

Volume of iron sphere = V = 6.1 $\times$ 10^{-4}m^3

(b) Given data:

Mass of lead = 200g

$$= \frac{200}{1000}\text{kg} = 0.2\text{kg}$$

Density of lead = ρ = 11300kgm^{-3}

To Find:

Volume of lead V = ?

$$\rho = \frac{m}{V}$$

$$11300 = \frac{0.2}{V}$$

$$V = \frac{0.2}{11300}$$

Volume of lead shot = V = 1.77 $\times$ 10^{-5}m^3

(c) ρ = 19300kgm^{-3}

m = 0.2kg

$$\rho = \frac{m}{V}$$

$$V = \frac{m}{\rho}$$

$V = \frac{0.2}{19300}$

Volume of gold bar = V = $1.04 \times 10^{-5}m^3$

7.4. The density of air is 1.3 kgm^{-3}. Find the mass of air in a room measuring 8m × 5m × 4m.

Ans. Given data:

Density of air = ρ = $1.3kgm^{-3}$

Mass of air = m = ?

Volume V = 8m × 5m × 4m

= $160m^3$

Solution:

Density = $\frac{\text{mass}}{\text{Volume}}$

$\rho = \frac{m}{V}$

$1.3 = \frac{m}{160}$

$m = 1.3 \times 160$

m = 208kg

7.5. A student presses her palm by her thumb with a force of 75N. How much would be the pressure under his thumb having contact area 1.5cm^2?

Ans. Given data:

Force = F = 75N

Area = A = $1.5cm^2 = \frac{1.5}{(100)^2 m^2}$

A = $1.5 \times 10^{-4}m^2$

To Find:

Pressure = P = ?

Solution:

$P = \frac{F}{A} = \frac{75}{1.5 \times 10^{-4}}$

P = $5 \times 10^5 Nm^{-2}$

7.6. The head of a pin is a square of side 10mm. Find the pressure on it due to a force of 20N. (SW 10-II)

Ans. Given data:

Side of square = L = 10mm

Area of square = A = L × L = 10 × 10 = $100mm^2$

(1m = 1000mm)

$A = \frac{100}{(1000)^2} m^2 = 1 \times 10^{-4}m^2$

Force = F = 20N

To Find:

Pressure = P = ?

Solution:

P = F/A

$$= \frac{20}{1 \times 10^{-4}}$$

$$= 20 \times 10^{4}$$

$$\mathbf{P = 2 \times 10^{5}Nm^{-2}}$$

7.7. A uniform rectangular block of wood 20cm × 7.5cm ×7.5cm and of mass 1000g stands on a horizontal surface with its longest edge vertical. Find (i) the pressure exerted by the block on the surface (ii) density of the wood. (MN 09-I)

Ans. Given data:

Area of block = 7.5 × 7.5 = $56.25cm^2$

A = $56.25 \times 10^{-4}m^2$

Mass of block = m = 1000g = 1kg

g = $9.8ms^{-2}$

To Find:

Pressure = P = ?

Density = ρ = ?

Solution:

$$\mathbf{P = \frac{F}{A} = \frac{mg}{A}}$$

$$\mathbf{P = \frac{10}{(56.25 \times 10^{-4})}}$$

$$\mathbf{P = 1778Nm^{-2}}$$

ii. Volume V = 20 × 7.5 × 7.5

= $1125cm^3$

V = $1125 \times 10^{-6}m^3$

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

$$\rho = \frac{m}{V}$$

$$= \frac{1}{1125 \times 10^{-6}} = \frac{10^6}{1125}$$

$$\boldsymbol{\rho} = \mathbf{889kgm^{-3}}$$

7.8. A cube of glass of 5cm side and mass 306g, has a cavity inside it. If the density of glass is $2.55gcm^{-3}$. Find the volume of the cavity.

Ans. Given Data:

Original volume of gas = V = 5cm ×5cm×5cm

V′ = $125cm^3$

Mass = m = 306

Density = ρ = $2.55g/cm^3$

To Find:

Volume of cavity = V = ?

Solution:

$$\text{Density} = \frac{\text{mass}}{\text{Volume}}$$

$$2.5 = \frac{306}{\text{Volume}}$$

$$V = \frac{306}{2.55}$$

Volume of glass = V = $120cm^3$
Volume of cavity =
Volume of while cube – Volume of glass
Volume of cavity = V′ – V
= 125 – 120
Volume of cavity = $5cm^3$

7.9. An object has weight 18N in air. Its weight is found to be 11.4N, when immersed in water. Calculate its density. Can you guess the material of the object?

Ans. Given data:

Weight in air = W_1 = 18N
Weight in water = W_2 = 11.4N
Density of water = ρ = $1000kgm^{-3}$

To Find:

Density of object ρ = ?

Solution:

$$\rho = \frac{w_1}{w_1 - w_2} \times \rho$$

$$= \left(\frac{18}{18-11.4}\right) \times 1000$$

ρ = $2727kgm^{-3}$

7.10. A solid block of wood of density $0.6gcm^{-3}$ weighs 3.06N in air. Determine (a) volume of the block (b) the volume of the block immersed when placed freely in a liquid of density $0.9gcm^{-3}$?

Ans. Given data:

Density of wood = $0.6gcm^{-3}$
Weight of wood in air = w_1 = 3.06N

$$w_1 = mg$$

$$m = \frac{w_1}{g} = \frac{3.06}{10}$$

$$= 0.306kg$$

$$= 306g$$

To Find:

Volume of block V_1 = ?
Volume when immersed in liquid V_2 = ?

Solution:

Density of liquid ρ = $10.9gcm^{-3}$

Part (a)

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

$$0.6 = \frac{306}{V_1} \Rightarrow V_1 = \frac{306}{0.6}$$

Volume of block = V_1 = $510cm^3$

Part (b)

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

$$\rho = \frac{m}{V_2}$$

$$0.9 = \frac{306}{V_2}$$

$$V_2 = \frac{306}{0.9}$$

Volume in water = V_2 = 340cm^3

7.11. The diameter of the piston of a hydraulic press is 30cm. How much force is required to lift a car weighing 20000N on its piston if the diameter of the piston of the pump is 3cm?

Ans. Givne data:

Weight on small piston = W = F_1 = 20000N

Diameter of large piston = D = 30cm

Radius of large piston R = $\frac{D}{2}$ = $\frac{30}{2}$ = 15cm = 0.15m

Area of large piston A = πR^2 = $3.14 \times (0.15)^2$

Diameter of small piston d = 3cm

Radius of small piston r = $\frac{3}{2}$ = 1.5cm = 0.015m

Area of small piston a = πr^2 = $3.14 \times (0.015)^2$

= 0.000706m

To Find:

Force on small piston F_2 = ?

Solution:

$$P_1 = P_2$$

$$\frac{F_1}{A} = \frac{F_2}{a}$$

$$\frac{20000}{\pi R^2} = \frac{F}{\pi r^2}$$

$$\frac{20000}{(0.0706)} = \frac{F_2}{(0.000706)}$$

F_2 = 200N

7.12. A steel wire of cross – sectional area 2×10^{-5}m^2 is stretched through 2mm by a force of 4000N. Find the Young's modulus of the wire. The length of the wire is 2m. (RWP 15-I) (GW 12-II) (LHR II-II)

Ans. Given data:

Cross – sectional area of wire = A = 2×10^{-5}m

Length of wire L_o = 2m

Force = 4000N

Increase in length = ΔL = 2mm = 2×10^{-3}m

To Find:

Young's modulus Y = ?

Solution:

$$Y = \frac{F.L_o}{A.\Delta L}$$

$$= \frac{4000 \times 2}{2 \times 10^{-5} \times 2 \times 10^{-2}}$$

$$= \frac{4000}{2 \times 10^{-8}}$$

$$= \frac{4 \times 10^{3} \times 10^{6}}{2}$$

$$\mathbf{Y = 2 \times 10^{11} Nm^{-2}}$$

Chapter # 8 (Thermal properties of matter)

- **Choose the correct answer from the following choices:**

i. Water freezes at: (LHR 14) (AK, LHR 13-II) (GW 14-I) (AK, GW 09-II) (SG 08-II) (BP 12-I) (LHR 08-I) (SG 15-II) (SW 15-I)
(a) 0°F (b) 32°F (c) -273K (d) 0K

ii. Normal human body temperature is: (DG, SW 14-I) (RWP, DG, BP, MN 13 I-II) (MN, AK 08-II) (SW 12-I) (SG 15-I) (BP, FB 15-II)
(a) 15°C (b) 37°C (c) 37°F (d) 98.6°C

iii. Mercury is used as thermometric material because it has: (BP 14-I) (BP 09-I) (MN 12-II) (AK 10-II) (BP II-II)
(a)uniform thermal expansion (b) low freezing point
(c) small heat capacity (d) all the above properties

iv. Which of the following material has large specific heat? (LHR 14-I) (SG 14-II) (GW 13 I-II) (LHR 09-I) (SG 10-I) (MN 15-II)
(a)copper (b) ice (c) water (d) mercury

v. Which of the following material has large value of temperature coefficient of linear expansion? (FB 14-II) (AK 13-I) (AK 08-II) (SG II-II) (MN 09-I)
(a)aluminium (b) gold (c) brass (d) steel

vi. What will be value of β for a solid for which α has value of $2 \times 10^{-5}K^{-1}$? (BP II-I) (SG 10-II) (GW 12-I)
(a) $2 \times 10^{-5}K^{-1}$ (b) $6 \times 10^{-5}K^{-1}$ (c) $8 \times 10^{-15}K^{-1}$ (d) $8 \times 10^{-5}K^{-1}$

vii. A large water reservoir keeps the temperature of nearby land moderate due to. (DG 12-I) (MN II-II)
(a)low temperature of water (b) low specific heat of water
(c)less absorption of heat (d) large specific heat of water

viii. Which of the following affects evaporation? (FB, DG, SW 14-II) (BP 14-I) (FB 09-I) (MN II-I) (SW 15-I)
(a)temperature (b) wind

(c)surface area of the liquid (d) all of the above

ANSWER:

i.	b.	ii.	b.	iii.	d.	iv.	c.	v.	a.
vi.	b.	vii.	d.	viii.	d.				

Short Questions

- **Write short answers of the following questions:**

8.1. Why does heat flow from hot body to cold body? (MN 14-II) (FB 13-II) (SG 15-I) (AK 15-II) (LHR 09-I) (SW 12-I)

Ans: Heat flows from hot body to cold body to attain the condition of thermal equilibrium.

8.2. What is meant by internal energy of a body? (SW, LHR 14-I) (RWP, SW 14-II) (LHR 13-II) (LHR 09-I) (GW 08-II) (FB 15-II) (MN 15-I)

Ans: **Internal energy of a body:** The sum of kinetic energy and potential energy associated with the atoms, molecules and particles of a body is called its internal energy.

8.3. Define the terms heat and temperature. (RWP 10-I) (LHR, RWP, MN 14-I) (MN, DG 14-II) (RWP, SG, LHR, MN, DG, AK, SW 13 I-II) (DG, MN, RWP 15-I) (RWP 15-II)

Ans: **Heat:** Heat is the form of energy that is transferred from one body to another in thermal contact with each other as a result of the difference of temperature between them.

Temperature: The temperature f a body is the degree of hotness or coldness of a body".

8.4. How does heating affect the motion of molecules of a gas? (RWP 14-I) (BP 14) (FB 12-I)

Ans: By heating the gas, its molecules get high kinetic energy and start to collide more randomly and motion of gas molecules is increased by heating. So, pressure and volume of gas molecules increase by heating.

8.5. Explain the volumetric thermal expansion. (MN 14-I) (AK, MN, FB, BP 14-II) (DG, GW 08-II) (FB, BP 15-I) (RWP 15-II)

Ans: **Volumetric thermal expansion:** It is usually expressed as a fractional change in volume per unit temperature change.

$$V = V_o (1 + \beta \Delta T)$$

8.6. What is thermometer? Why mercury is preferred as thermometric substance? (SW, AK 14-I) (SW, DG 14-II) (AK, BP 13 I-II) (AK, GW 13-II) (FB 09-II) (MN II-II) (BP 15-I)

Ans: **Thermometer:** A thermometer is a device which is used to measure the temperature of a body. Mercury is preferred as a thermometric substance due to following properties.

Mercury as thermometric substance:

- It is easily visible.
- It has uniform thermal expansion.
- It has low freezing point and high boiling point.
- It has a small specific heat capacity.

8.7. Define specific heat. How would you find the specific heat of a solid? (GW, MN 14-II) (FB, RWP, MN, BP 13 I-II) (DG, GW 13-II) (MN, SW, LHR, BP 14-I) (LHR, BP 15-I)

Ans: **Specific heat:**"The specific heat of a substance is the amount of heat required to raise the temperature of 1kg mass of that substance through 1K".

Specific heat of any substance can be found out by using following formula:

$$c = \frac{\Delta Q}{m\Delta T}$$

c is the specific heat capacity.
ΔQis the amount of heat absorbed by the body.
m is the mass of the body.
ΔT is the change of temperature.

8.8. Define latent heat of vaporization. (BP, GW, RWP 14-II) (AK, BP, DG 13 I-II) (FB 15-I) (FB 15-II)

Ans: **Latent heat of vaporization:**"The quantity of heat that changes unit mass of a liquid completely into gas at its boiling point without any change in its temperature is called its latent heat of vaporization denoted by H_v".

Formula:$H_v = \Delta Q_v/m$

Unit: Jkg^{-1}

8.9. Define and explain latent heat of fusion. (SW, RWP 13-II) (GW, RWP, SG 13-I) (FB, DG, MN, BP, AK 14 I-II) (RWP 15-I) (RWP 15-II)

Ans: **Latent heat of fusion:**Latenet heat of fusion is the amount of thermal energy, which must be absorbed for 1 mole of substance to change its state from solid to liquid without change in temperature, is called latent heat of fusion.

Unit: Its SI unit is Jkg^{-1}.

Formula:$H_f = \frac{\Delta Qf}{m}$

8.10. What is meant by evaporation? On what factors the evaporation of a liquid depends? Explain how cooling is produced by evaporation.
(AK, SG 14-II) (AK, BP, MN 13 I-II) (LHR 13-I) (FB 15-II) (RWP 15-I)

Ans: **Evaporation:** Evaporation is escaping out of fast moving water molecules from the surface of a liquid without heating.

Factors:

i. temperature **ii.**surface area **iii.** Wind **iv.**nature of liquid

Cooling by evaporation: During evaporation molecules having greater kinetic energy escape out from the surface of a liquid, while the molecules having lower kineticenergies are left behind. In this way evaporation produces cooling by lowering the average kinetic energy and the temperature of molecules of a liquid.

Important Formulas

- $T_k = T^oC + 273$
- $oF = 1.8^oC + 32$
- $V = V_o(1 + \beta\Delta T)$
- $L = L_o(1 + \alpha\Delta T)$
- $P = \frac{Q}{t}$
- $Q = mc\Delta T$
- $Q_f = mH_f$
- $Q_v = mH_v$
- $\Delta T = T - T_o$

Units:

- Co-efficient of linear thermal expansion = α = K^{-1}
- Co-efficient of volume expansion = β = K^{-1}
- Specific heat capacity = c = $Jkg^{-1}K^{-1}$

- Latent heat of fusion = H_f = Jkg^{-1}
- Latent heat of vaporization = H_v = Jkg^{-1}
- Specific heat of water = c = $4200Jkg^{-1}K^{-1}$

Numericals

8.1. Temperature of water in a beaker is 50°C. What is its value in Fahrenheit scale? (AK, LHR 14-II) (DG, RWP 13-I) (SG 13-II) (FB 13-II) (FB 14-I) (SG 15-I)

Ans. Given data:

T°C = 50°C

To Find:

°F = ?

Solution:

Since °F = 1.8oC + 32°

= 1.8 × 50 + 32°

= 90 + 32

°F = 122°F

8.2. Normal human body temperature is 98.6°F. Convert it into Celsius scale and Kelvin scale. (GW, AK 13-II) (GW 13-I) (MN, GW, SW 14-I) (SW 15-II) (FB 15-I)

Ans. Solution:

T°F = 98.6°F

T°C = ?

T_k = ?

We know that

T_F = 1.8 T°C + 32

98.6 – 32 = 1.8 T°C

66.6 = 1.8 T°C

T°C = $\frac{66.6}{1.8}$

T°C = 37°C

Now

T_k = T°C + 273

= 37 + 273

T_k = 310K

8.3. Calcualte the increase in the length of an aluminum bar 2m long when heated form 0o to 20°C. If thermal coefficient of linear expansion of aluminium is $2.5 \times 10^{-5}K^{-1}$. (MN 08-II)

Ans. Given data:

Original length = L_o = 2m

T_o = 0^oC = 0 + 273 = 273

T^oC = 20^oC = 20 + 273 = 293K

ΔT = $T - T_o$

= 293 – 273

ΔT = 20K

Co-efficient of linear expansion = $\propto$ = $2.5 \times 10^{-5}K^{-1}$

To Find:

Increase in length = ΔL = ?

Solution:

L = $L_o (1 + \propto \Delta T)$

= 2[1+ (2.5 × 10-5) (20)]

= 2 (1 + 0.0005)

= 2.001m

Increase in length = ΔL = $L - L_o$

= 2.001– 2

ΔL = .001m

(1m = 100cm)

ΔL = 0.001 × 100cm

Increase in length = ΔL = 0.1cm

8.4. A balloon contains $1.2m^3$ air at 15^oC. Find its volume at 40^oC. Thermal co-eficientg of volume expansion of air is 3.67 × 10-3K-1. (SG 08-II) (GW II-II)

Ans. Given data:

V_o = $1.2m^3$

T_o = 15 + 273 = 288J

T = 40 + 273 = 313K

ΔT = $T - T_o$ = 313 – 288 = 25K

Thermal co-efficient of volme expansion = β = $3.67 \times 10^{-3}K^{-1}$

To Find:

V = ?

Solution:

Now V = $V_o (1 + \beta \Delta T)$

= $1.2 [1 + 367 \times 10^{-3}) (25)]$

= 1.2 (1 + 0.09175)

= 1.2 (1.0917)

Volume at 40^oC = V = $1.3m^3$

8.5. How much heat is required to increase the temperature of 0.5kg of water from 100^oC to 65^oC? (SW, RWP 14-II) (FB, RWP 15-II)

Ans. Given data:

m = 0.5kg

T_o = $10^oC + 273$ = 283K

$T = 65^oC + 273 = 338K$

$\Delta T = T - T_o$

$\Delta T = 338 - 283 = 55K$

Specific heat capacity of water = c = $4200Jkg^{-1}K^{-1}$

Required:

Heat = Q = ?

Solution:

$$C = \frac{Q}{m\Delta T}$$

$$Q = mc\Delta T$$

$$= (4200)(0.5)(55)$$

$$Q = 115500J$$

Required heat is 115500J

8.6. An electric heater supplies heat at the rate of 1000 joule per second. How much tme is required to raise the temperature of 200g of water from 20ºC to 90ºC?

Ans. Given data:

Power = P = 1000J/sec

Mass = m = 200g = $\frac{200}{1000}$ = 0.2kg

$T_o = 20^oC + 273 = 293K$

$T = 90^oC + 273 = 363K$

$\Delta T = T - T_o = 363 - 293 = 70K$

Specific heat capacity of water c = $4200Jkg^{-1}K^{-1}$

To Find:

Time = t = ?

Solution:

$$C = \frac{Q}{m\Delta T}$$

$$Q = mc\Delta T$$

$$= (0.2)(42000)(70)$$

$$Q = 58800J$$

$$P = \frac{Q}{t}$$

$$1000 = \frac{58800}{t}$$

$$t = \frac{58800}{1000}$$

$$\mathbf{t = 58.8sec}$$

8.7. How much ice will melt by 50000J of heat? Latent heat of fusion of ice = 336000Jkg^{-1}. (MN 12-I)

Ans. Given data:

Q_f = 50, 000J

Latent heat of fusion of ice = H_f = $336000Jkg^{-1}$

To Find:

Mass of ice = m = ?

Solution:

$Q_f = mH_f$

$H_f = \frac{Q_f}{m}$

$336000 = \frac{50000}{m}$

$m = \frac{50000}{336000}$

$m = 0.15kg$

$m = 0.15 \times 1000g$

$m = 150g$

8.8. Find the quantity of heat needed to melt 100g of ice at – 10°C at itno water at 10°C. (Note: Specific heat of ice is $2100Jkg^{-1}K^{-1}$. Specific heat of water is $4200Jkg^{-1}K^{-1}$. Latent heat of fusion of ice is $336000Jkg^{-1}$) (GW II-I)

Ans. Given data:

Mass of ice = 100g = 0.1kg

Change in temp of ice = ΔT

= $T_1 - T_2$

= 0°C – (-10°C)

= 10°C

Change in temp of water = ΔT

= $T - T_2$

= 10°C – 0°C

= 10°C

Specific heat of ice = $2100Jkg^{-1}K^{-1}$

Specific heat of water = $4200Jkg^{-1}K^{-1}$

Latent heat of fusion of ice = $336000Jkg^{-1}$

Required:

Heat = Q = ?

Solution:

i. Heat gained by ice from – 10°C to 0°C =

$Q_1 = mc\Delta T$

$Q_1 = 0.1 \times 2100 \times 10$

$Q_1 = 2100J$

ii. Heat required by ice to melt = Q_2 = mt

$Q_2 = 0.1 \times 3360000$

$Q_2 = 33600J$

iii. Heat required to raise temp from 0°C to 10°C =

$Q_3 = mc\Delta T$

$= 0.1 \times 4200 \times 10$

$Q_3 = 4200J$

Total heat required = $Q = Q_1 + Q_2 + Q_3$

= 2100 + 33600 + 4200

Q = 39900J

8.9. How much heat is required to change 100g of water at 100°C into steam? Latent heat of vaporization of water is $2.26 \times 10^6 Jkg^{-1}$. (RWP 15-I) (GW 12-II) (LHR II-II)

Ans. Given data:

Mass of water = m = 100g

M = $\frac{100}{1000}$ = 0.1kg

T = 100°C

Latent heat of vaporization of water = Hv = $2.26 \times 10^6 Jkg^{-1}$

To Find:

Q_v = ?

Solution:

$Q_v = mH_v$

$H_v = \frac{Q_v}{m}$

$2.26 \times 10^6 = \frac{Q_v}{0.1}$

$2.26 \times 10^6 \times 0.1 = Q_v$

$2.26 \times 10^6 J = Q_v$

8.10. Find the temperature of water after passing 5g of steam at 100°C through 500g of water at 10°C. (Note: Specific heat of water is $4200 Jkg^{-1}K^{-1}$, Latent heat of vaporization of water Is $2.26 \times 10^6 Jkg^{-1}$). (SG 08-I)

Ans. Given data:

Mass of steam = m_1 = 5g = 0.005kg

Temperature of steam = T_1 = 100°C

Mass of water m_2 = 0.5kg

Temperature of water = T_2 = 10°C

Latent heat of vaporization = L = $2.26 \times 10^6 Jkg^{-1}$

Specific heat of water = C = $4200 Jkg^{-1}$

To Find:

Final temperature = T_3 = ?

Solution:

i. Heat required by water to vaporize = Q_1 = mL

= $0.005 \times 2.26 \times 10^6 Jkg^{-1}$

$Q_1 = 11.3 \times 10^3 J$

ii. Heat required to attain T_3 =

$Q_2 = m1c\Delta T$

$\Delta T = 100 - T_3$

$Q_2 = 0.005 \times 4200 \times (100 - T_3)$

$Q_2 = 21(100 - T_3)$

iii. Heat gained by water = $Q_3 = m_2c\Delta T$

$Q_3 = Q_1 + Q_2$

$2100 (T_3 - 10) = (11.3 \times 10_3) + 21(100 - T_3)$

$2100T_3 - 21000 = 11300 + 2100 - 21T_3$

$2100T_2 + 21T_3$	=	11300 + 2100 + 21000
$2121T_3$	=	34400
T_3	=	$\frac{34400}{2121}$
$\mathbf{T_3}$	=	**16.2°C**

Chapter # 9 (Transfer of heat)

- **Choose the correct answer from the following choices:**

i. In solids, heat is transferred by: (SG, MN, AK, BP 13-II) (BP 12-I) (LHR, GW 09-II) (LHR 12-I) (RWP 08-II) (RWP II-I) (RWP 15-II)
(a) radiation (b) conduction (c) convection (d) absorption

ii. What happens to the thermal conductivity of a wall if its thickness is doubled? (SW, GW 14-I) (GW II 13-I) (SW 12-I) (GW II-II) (FB 09-I) (FB 15-II)
(a) becomes double (b) remains the same (c) becomes half (d) becomes one fourth

iii. Metals are good conductor of heat due to the: (MN II-14-II) (BP 12-I)
(a) free electrons (b) big size of their molecules
(c) small size of their molecules (d) rapid vibrations of their atoms

iv. In gases, heat is mainly transferred by. (RWP, LHR 14-I) (GW, FB, LHR 13-I-II) (RWP 14-II) (LHR 12-II) (BP II-II) (LHR, RWP 15-I)
(a) Conduction (b) molecular collision (c) convection (d) radiation

v. Convection of heat is the process of heat transfer due to the: (SG 09-I)
(a) random motion of molecules (b) downward movment of molecules
(c) upward movement of molecules (d) free movement of molecules

vi. False ceiling is done to (SG 14-II) (SW, SG 09-II) (MN 15-I)
(a)lower the height of ceiling (b) keep the roof clean
(c)cool the room (d) insulate the ceiling

vii. Rooms are heated using gas heaters by. (LHR, FB 14) (DG 13-I) (SW 13-II) (DG 12-I) (FB II-I) (RWP 08- I)
(a)conduction only (b) convection and radiation(c) radiation only (d) convection only

viii. Land breeze blows from: (BP 14-I) (SW 14-II) (BP, SW, MN II-I) (SW 12-II)
(a)sea to land during night (b) sea to land during the day
(c)land to sea during night (d) land to sea during the day

ix. Which of the following is a good radiator of heat? (MN 14-I) (FB 13-I) (FB 08-I)
(a)a shining silvered surface (b) a dull black surface
(c)a white surface (d) a green coloured surface

ANSWER:

i.	b.	**ii.**	c.	**iii.**	a.	**iv.**	b.	**v.**	c.
vi.	d.	**vii.**	b.	**viii.**	c.	**ix.**	b.		

Short Questions

- **Write short answers of the following questions:**

9.1. Why metals are good conductors of heat? (GW 14-II) (DG, AK 14-I) (RWP 13-I) (LHR 08-II) (GW II-II) (MN 15-II)

Ans: Metals are good conductors of heat because they possess the freely moving electrons.

9.2. Explain why. (MN 13-I) (FB 14-I)

(a) A metal feels colder to touch than wood kept in a cold place!

(b) Land breeze blows from land towards sea!

(c) Double walled glas vessel is used in thermoss flask!

(d) Deserts soon get hot during the day and soon get cold after sunset!

Ans: **a.**A metal feels colder to touch than wood because it is a good conductor due to free electrons. So it cols down more rapidly as compared to wood. Wood is an example of insulator.

b. At night, the land cools faster than the sea. Therefore, air above the sea is warmer, rises up and colder air from the land begins to move towards the sea.

c. Double waled glass vessel is used in thermos flask because double walled glass vessel has air between two glass walls that provide insulation.

d. Deserts soon get hot during the day and soon get cold after sunset because sand in the deserts has very low value of specific heat. It cools down and warms up fastly.

9.3. Why transfer of heat in fluids takes places by convection? (GW 14-I) (LHR 13-I) (BP 13-II)

Ans: Transfer of heat in fluids takes palce by convection because fluids are not good conductor of heat. As, molecules of fluids are able to move freely, hence heat transfer takes place by convection.

9.4. Why conduction of heat does not take place in gases? (FB 14-II) (FB 08-II) (RWP 12-I) (SG II-I) (LHR II-I)

Ans: Conduction of heat does not take place in gases because gases are bad conductor of heat.

9.5. What measures do you suggest to conserve energy in houses? (RWP 14-I-II) (DG 12-I, 13-I) (GW 08-II) (LHR 12-II)

Ans: **<u>Measures to conserve energy:</u>**

i. Hot water tanks are insulated by plastic or foam lagging.

ii. The bottoms of cooking pots are made black to increase the absorption of heat from fire.

iii. Solar energy is used by solar panel in houses. The solar energy is converted into electric energy.

iv. Switch off the electric appliance when these are not used by humans.

v.Eenergy in houses can be conserved by using energy savers instead of bulbs.

9.6. What is meant by convection current? (AK, SW 14-I) (SW, GW 14-II) (LHR 13-II) (RWP, BP 13 I-II) (RWP 09-I) (MN 15-II)

Ans: **<u>Convection current:</u>** Hot air rises up creating gap which in filled by colder air, this air also gets warm and rises up. That is how, convection currents are produced.

9.7. How does heat reach us from the sun? (BP 13-II) (BP 14-I) (AK 10-I) (SW 12-II) (BP 12-I)

Ans: Heat reaches us from the sun through radiation process.

9.8. Suggest a simple activity to show convection of heat in gases not given in the book.

Ans: An example of convection in daily life is when we use a fire place of heat in our home, as the fire heats up the air in front of it, the hot air rises up as it is less dense and than in turn

pushes the cool air down so that it is heated and then rises, this motion is called convection currents and in the reaction fire place air effective to heat us.

9.9. How various surfaces can be compared by a Leslie cube?

Ans: The rate at which various surface absorb heat is different from one another. So, on the basis of their ability to absorb heat through different surfaces can be compared by Leslie's cube.

9.10. Explain the impact of green house effect in global warming. (BP 08-I, 14) (FB 14-II) (RWP 13-II) (GW 09-I, 14-I) (SW 12-I)

Ans: During the recent years, the percentage of carbon dioxide has been increased considerably. This has caused an increase in the average temperature of the earth by trapping more heat due to greenhouse effect. This phenomenon is known as global warming.

This is serious implications for global climate.

9.11. What is greenhouse effect? (LHR, BP, FB 15-I) (SW 13-I) (BP 14-I) (SG 14-II) (AK, SW, BP, SG 13-II)(RWP, GW, SW, LHR 14-I-II)

Ans: **Greenhouse effect:** Greenhouse effect is the result of infrared light not being able to transmit it back through the atmosphere into space after it has been radiated to the earth from the sun.

Important Formulas

- $\frac{Q}{t} = \frac{kA\Delta T}{L}$ or $Q = \frac{tkA\Delta T}{L}$
- Rate of flow of heat = $\frac{Q}{t}$
- Thermal conductivity = k = $Wm^{-1}K^{-1}$

Numericals

9.1. The concrete roof of a house of thickness 20cm has an area $200m^2$. The temperature inside the house is 15°C and outside is 35°C. Find the rate at which thermal energy will be conducted through the roof. The value of k for concrete is $0.65Wm^{-1}K^{-1}$.

Ans. Given data:

$L = 2cm = \frac{20}{100} = 0.2m$

$A = 200m^2$

$T_1 = 35°C$

$= 35 + 273 = 308K$

$T_2 = 15°C$

$= 15 + 273 = 288K$

$\Delta T = T_1 - T_2$

$= 308 - 288 = 20K$

$\Delta T = 20K$

Thermal conductivity = $k = 0.65\ Wm^{-1}K^{-1}$

To Find:

Rate of flow = $\frac{Q}{t}$ = ?

Solution:

$$\frac{Q}{t} = \frac{kA(T_1 - T_2)}{L} = \frac{kA\Delta T}{L}$$

$$= \frac{(0.65)(200)(20)}{0.2}$$

Rate of flow = **$13000 Js^{-1}$**

9.2. How much heat is lost in an hour through a glass window measuring 2.0m by 2.5m when inside temperature is 25°C and that of outside is 5°C. The thicknes of glass is 0.8cm and the value of k for glass is $0.8 Wm^{-1}K^{-1}$?

Ans. Given data:

t = 1 hour= 3600 sec

Area = A = 2×2.5 = $5m^2$

Length = L = 0.8cm = $\frac{0.8}{100}$ = 0.008m

T1 = 25°C – 25 + 273 = 298K

T2 = 5°C – 5 + 273 = 278K

$\Delta T = T_1 - T_2$

ΔT = 298 – 278 = 20K

Thermal conductivity = k = $0.8 Wm^{-1}K^{-1}$

To Find:

Heat = Q = ?

Solution:

$$\frac{Q}{t} = \frac{kA(T_1 - T_2)}{L}$$

$$= t\,\frac{kA(T_1 - T_2)}{L}$$

$$= \frac{3600 \times 0.8 \times 5(20)}{0.008}$$

Rate of flow = **$3.6 \times 10^7 J$**